2190A
Digital Thermometer

Instruction Manual

P/N 489229
June 1978
Rev.2, 9/88

FLUKE

WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive:

The JOHN FLUKE MFG. CO., INC., warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of 1-year from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90-days), or any product or parts which have been subject to misuse, neglect, accident, or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, John Fluke Mfg. Co., Inc., will repair and calibrate an instrument returned to an authorized Service Facility within 1 year of the original purchase; provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within 1 year of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident, or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

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1. Notify the JOHN FLUKE MFG. CO., INC., or nearest Service facility, giving full details of the difficulty, and include the model number, type number, and serial number. On receipt of this information, service data, or shipping instructions will be forwarded to you.

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All shipments of JOHN FLUKE MFG. CO., INC., instruments should be made via United Parcel Service or "Best Way"* prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid and of adequate size. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon original delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

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*For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206

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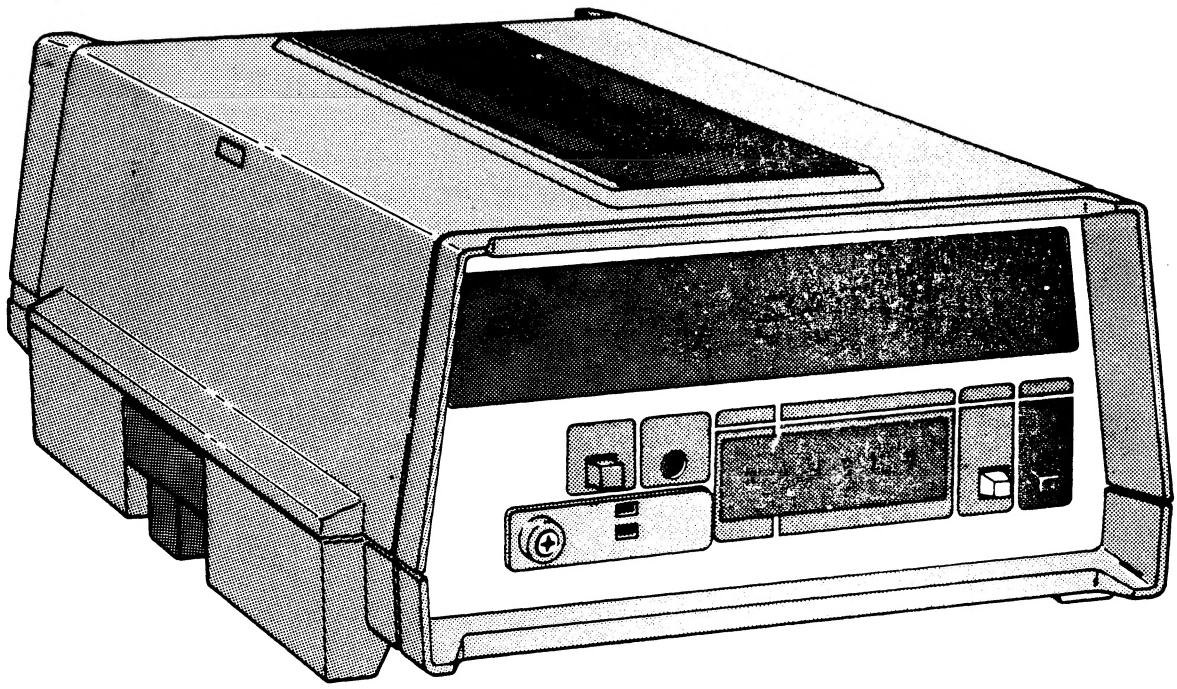


2190A Digital Thermometer

Section 1
Introduction & Specifications

1-1. INTRODUCTION

1-2. The Model 2190A Digital Thermometer is a portable, stackable, five digit, thermocouple thermometer capable of temperature measurements over a range of -252°C to +2471°C (-486°F to +4480°F) with a resolution of 0.1°. The instrument features automatic reference-junction compensation, eliminating the requirement for an ice bath reference-junction; front panel switch selection of Fahrenheit or Celsius readings; switch selectable thermocouple inputs; switch selectable input line voltage; dual-slope measurement techniques; and digital linearization (microcomputer controlled) of the thermocouple inputs.

1-3. The instrument display has six high-intensity, seven segment LEDs, and leading zero suppression. Five of the LEDs are used to display numeric data, including a minus sign for negative temperature readings. The remaining LED displays the selected temperature scale character (°F or °C). The symbol "O.C." is displayed when an open-thermocouple is detected at the thermocouple input terminals.

1-4. Screw-type input connectors, on a removable module, are provided for attaching the selected thermocouple. The terminals are an integral part of an isothermal block which serves as a portion of the reference-junction compensation circuit. This circuit removes the need for an ice bath reference junction (0°C or 32°F) since it provides the electrical equivalent automatically.

1-5. Selection of the temperature scale for display is made with a front panel pushbutton. The scale selected, Celsius or Fahrenheit, is displayed as either the character °C or °F as the last character in the temperature reading. A scale change can be made at any time, and has no effect on the calibration of the instrument.

1-6. The measurement range of the 2190A is determined by the type of thermocouple used as the input device. The type of microcomputer installed in your instrument will determine the type of thermocouples that may be used. The specifications table identifies the type of thermocouples that are presently available for use in the 2190A, and Section 2 gives the procedure for identifying the microcomputer type. The version required must be specified when ordering the instrument. Choice of the thermocouple type is accomplished by selecting the applicable switch position on the removable input module using the table printed beside the switch on the pcb. Recalibration is not required if the thermocouple type is changed.

NOTE

The letter C is not an ISA/ANSI thermocouple desgnation. C is used for convenience only to represent Tungsten-5% Rhenium versus Tungsten-26% Rhenium alloy.

1-7. The instrument is in a PTI (Portable Test Instrument) case. This lightweight, durable plastic case makes the instrument truly portable when used with the Y2003 or Y2009 external power sources and can be stacked for one handle portability.

1-8. Options and accessories available for the 2190A are listed in Tables 1-1 and 1-2 respectively. Detailed information concerning each item listed is given in Section 6 of this manual, Option and Accessory Information.

Table 1-1. 2190A Options

OPTION	DESCRIPTION
21X0A-002	Output Option
21X0A-004	IEEE-488 Interface Option
21X0A-006	Limits Option

1-9. Four input line voltages are available for switch selection. Selection may be made for 100, 120, 220 or 240 volts ±10%, as required to meet local conditions. Frequency may vary between 50 to 440 Hertz for all voltage selections. Refer to Section 4 of this manual on how to change the selected input line voltage. The instrument will also operate with an external input of 12V dc.

1-10. SPECIFICATIONS

1-11. Specifications for the 2190A Digital Thermometer are given in Table 1-3.

Table 1-2. 2190A Accessories

ACCESSORIES	DESCRIPTION	ACCESSORIES	DESCRIPTION
Y2001	Multipoint Selector, Thermocouple	Y2024	Power Cord, 3-way
Y2003	Calibrator, Thermocouple Indicator	Y2026B	Cable, Output Unit, RS-232-C
Y2009	Battery Pack, 12V Rechargeable	Y2030	Thermocouple Input Module
Y2010	Rack Panel PTI, single, A size (for Y2001)	P20J	J-Type Thermocouple Probe
Y2014	Rack Panel PTI, single, C size (for 2190A, Y2002 and Y2023)	P20K	K-Type Thermocouple Probe
		P20T	T-Type Thermocouple Probe
Y2015	Rack Panel PTI, double, C size (for 2190A, Y2002 and Y2023)	P20E	E-Type Thermocouple Probe
Y2016	7 inch Rack Adapter PTI, single, D size		
Y2017	7 inch Rack Adapter PTI, double, D size		
Y2020	Panel Mount PTI-DIN, C size (for 2190A, Y2002 and Y2023)		
Y2021	145 mm Panel Mount PTI, D size		
Y2022	Divider, Thermometer Calibrator		

Table 1-3. Specifications

2190A Digital Thermometer

Thermocouple Types: Determined by type of microcomputer.

MICROCOMPUTER TYPE	THERMOCOUPLE TYPE
1	J, K, T, C, and R
2	J, K, E, S, and R
3	JDIN*, K, TDIN*, B and R

*European standard

Display: °F or °C, switch-selectable, 7-segment LED's 1.1 cm high.
Resolution: 0.1°.
Measurement Method: Dual slope integration, under microcomputer control. 100 ms integration period, three readings per second.
Linearization Technique: Computer algorithm, 4th order curve fit.
Warm-Up to Rated Accuracy: 5 minutes.
Reference Junction Compensation: 0.005° per degree from 25°C.
Safety: PROTECTION CLASS 1 (Relates solely to insulation or grounding properties further defined in IEC 348.)

Temperature Coefficient: ±15 ppm/°C from 25°C.
Stability: ±175 ppm in 90 days, 200 ppm per year.
Common Mode Rejection: ≥160 dB at dc, 50, 60, and 400 Hz ±0.1%, with 100Ω unbalance at input.
Common Mode Voltage: 350V dc or 250V ac rms max.
Normal Mode Rejection: ≥90 dB at dc, 50, 60, and 400 Hz ±0.1%.
Zero Drift: Automatic zero correction.
Input Connection: Two wires, on screw terminal isothermal block.
Input Impedance: 1000 MΩ at dc.
Max. Source Impedance: 2 kΩ.
Power: 12V dc or 100, 120, 220 or 240V ac ±10%, selectable, 50 to 400 Hz; 8W typical.
Size and Weight: Style C case, 2.1 kg (4 lbs. 9 oz.), typical.
Overrange (Overload) Detection: The thermometer display flashes either positive full scale or negative full scale depending on the polarity of the overload (voltage).
Open Circuit Detection: A source impedance of 3 kΩ or more causes the thermometer to display a flashing "O.C.". An internal switch allows a user to simulate a + overload or – overload which can be used to control limits or alarms for failsafe control.

Table 1-3. Specifications (cont)

2190A Instrument Accuracy Specifications**

MICROCOMPUTER TYPE #1

Thermocouples		Maximum Error					
		±Degrees C			±Degrees F		
Type	Applicable Portion of Temp. Range, °C	At Cal.	90 Dys 20°C to 30°C	1 Yr 15°C to 35°C	At Cal.	90 Dys 68°F to 86°F	1 Yr 59°F to 95°F
J	-128 to 0	0.18	0.19	0.21	0.20	0.23	0.26
	0 to 900	0.18	0.31	0.36	0.20	0.47	0.58
K	-132 to 0	0.18	0.19	0.21	0.30	0.33	0.37
	0 to 1350	0.18	0.39	0.47	0.30	0.72	0.87
T	-243 to 0	0.18	0.20	0.22	0.30	0.35	0.39
	0 to 400	0.18	0.22	0.25	0.30	0.41	0.46
R	0 to 1708	0.31	0.59	0.70	0.47	1.01	1.20
C	0 to 2471	0.18	0.60	0.75	0.30	1.11	1.37

MICROCOMPUTER TYPE #2

Thermocouples		Maximum Error					
		±Degrees C			±Degrees F		
Type	Applicable Portion of Temp. Range, °C	At Cal.	90 Dys 20°C to 30°C	1 Yr 15°C to 35°C	At Cal.	90 Dys 68°F to 86°F	1 Yr 59°F to 95°F
J	-128 to 0	0.18	0.19	0.21	0.20	0.23	0.26
	0 to 900	0.18	0.31	0.36	0.20	0.47	0.58
K	-132 to 0	0.18	0.19	0.21	0.30	0.33	0.37
	0 to 1350	0.18	0.39	0.47	0.30	0.72	0.87
E	-252 to 0	0.18	0.20	0.22	0.30	0.35	0.40
	0 to 1000	0.18	0.33	0.39	0.30	0.61	0.72
R	0 to 1708	0.31	0.59	0.70	0.47	1.01	1.20
S	0 to 1685	0.22	0.50	0.60	0.38	0.92	1.10

MICROCOMPUTER TYPE #3

Thermocouples		Maximum Error					
		±Degrees C			±Degrees F		
Type	Applicable Portion of Temp. Range, °C	At Cal.	90 Dys 20°C to 30°C	1 Yr 15°C to 35°C	At Cal.	90 Dys 68°F to 86°F	1 Yr 59°F to 95°F
J DIN*	-100 to 0	0.18	0.19	0.20	0.30	0.32	0.36
	0 to 760	0.18	0.28	0.33	0.30	0.52	0.61
K	-50 to 0	0.18	0.18	0.20	0.20	0.22	0.25
	0 to 1372	0.18	0.39	0.48	0.20	0.63	0.78
T DIN*	-200 to 0	0.18	0.20	0.21	0.30	0.34	0.38
	0 to 400	0.18	0.22	0.25	0.30	0.41	0.46
B	420 to 1815	0.21	0.52	0.62	0.37	0.95	1.15
R	140 to 1700	0.18	0.46	0.56	0.20	0.74	0.93

*European Standard

**Note: Instrument accuracy does not include thermocouple errors such as non-conformity to standard curve.

Table 1-3. Specifications (cont)

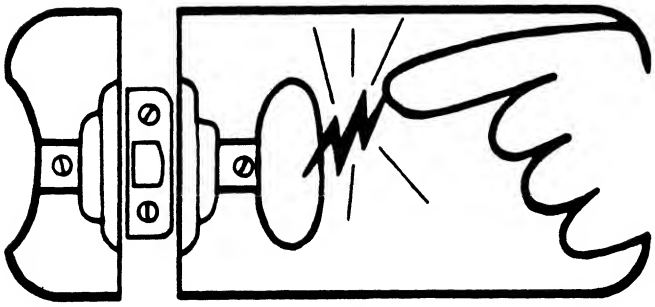
PTI Common Specifications (2190A and Accessories)
Storage Temperature: –40°C to +75°C, except Y2003 or Y2009 is 0 to 40°C.
Operating Temperature: 0 to 50°C, except Y2003 and Y2009 is 0 to 40°C.
Relative Humidity: ≤80%, non-condensing, from 0 to 50°C.
Shock and Vibration: Meets MIL-T-2800 specifications.

PTI Case Dimensions
Style A: 5.72 cm H x 20.45 cm W x 32.64 cm D (2.25 in. H x 8.05 in.W x 12.85 in. D).
Style B: 8.20 cm H x 20.45 cm W x 32.64 cm D (3.23 in. H x 8.05 in. W x 12.85 in. D).
Style C: 10.49 cm H x 20.45 cm W x 32.64 cm D (4.13 in H x 8.05 in. W x 12.85 in. D).

static awareness

A Message From

John Fluke Mfg. Co., Inc.

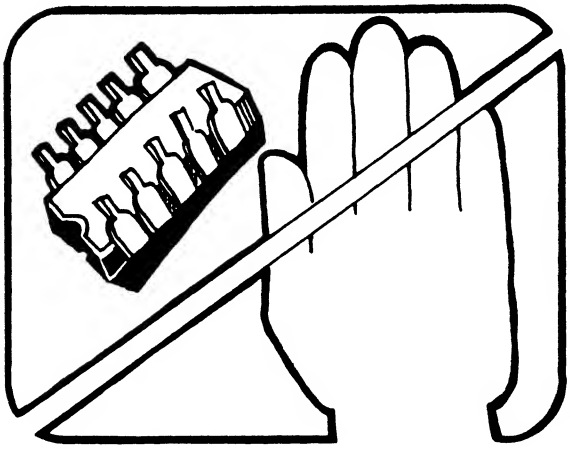


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

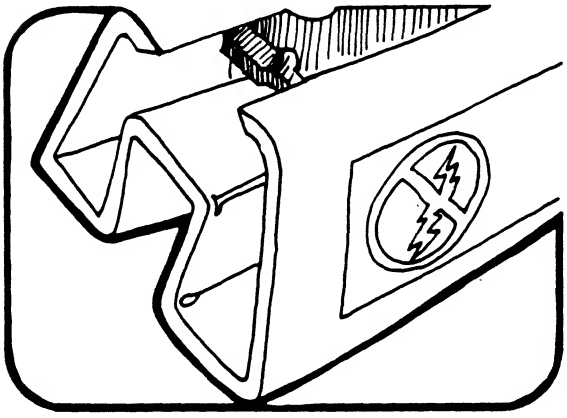
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol "⊗"

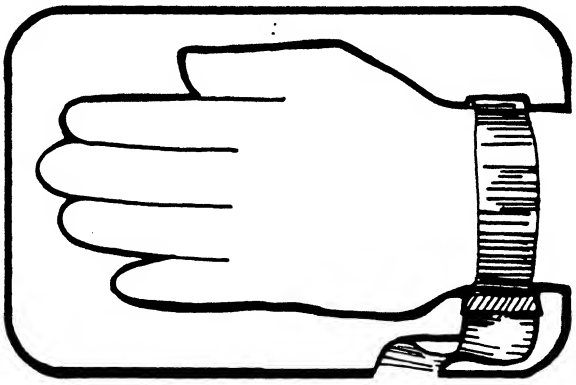
The following practices should be followed to minimize damage to S.S. devices.



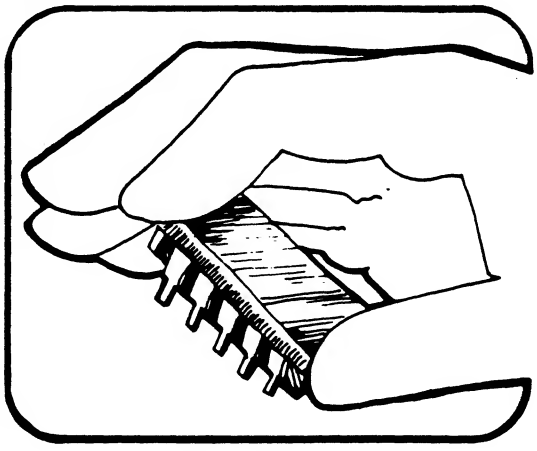
1. MINIMIZE HANDLING



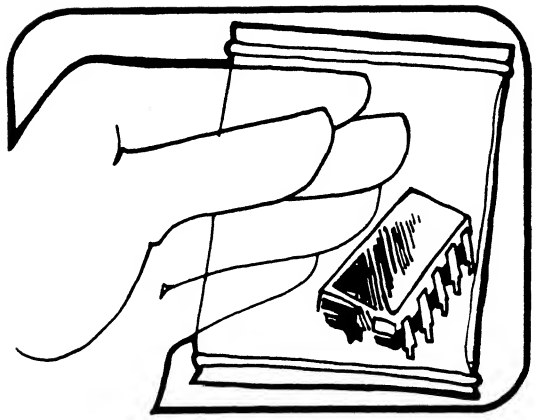
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



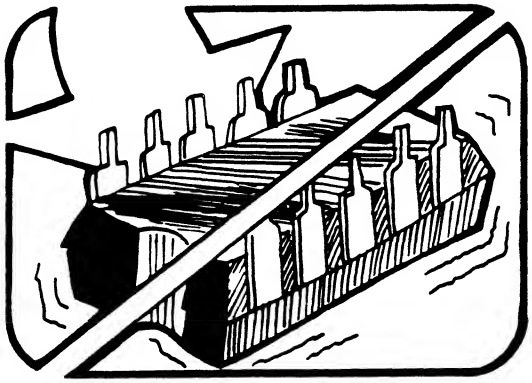
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



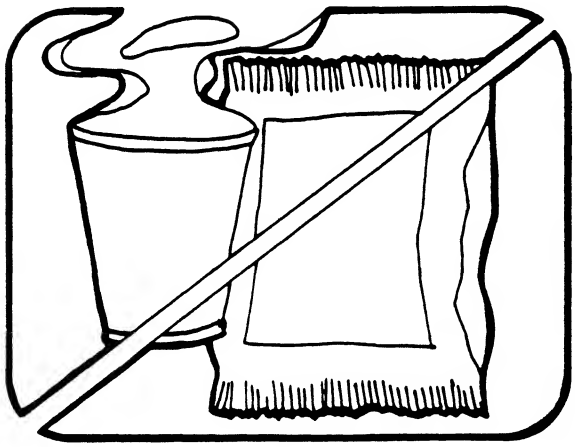
4. HANDLE S.S. DEVICES BY THE BODY



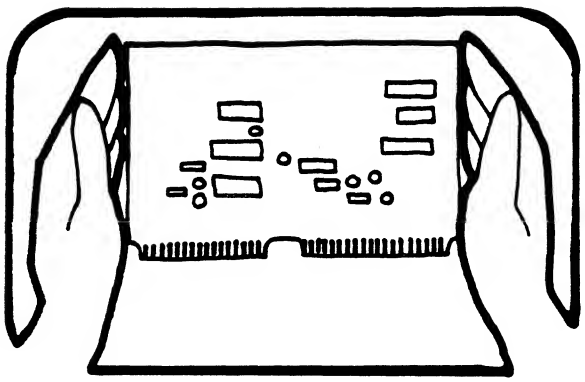
5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT



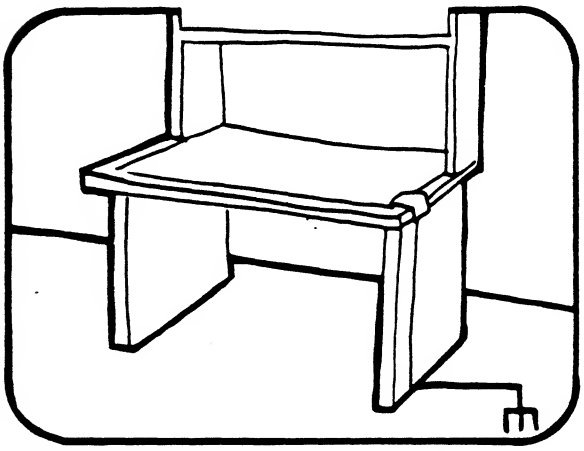
6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA



8. WHEN REMOVING PLUG-IN ASSEMBLIES, HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR HELPS TO PROTECT INSTALLED SS DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION
10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.
11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

A complete line of static shielding bags and accessories is available from Fluke Parts Department, Telephone 800-526-4731 or write to:

JOHN FLUKE MFG. CO., INC.
PARTS DEPT. M/S 86
9028 EVERGREEN WAY
EVERETT, WA 98204

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Section 2
Operating Instructions

2-1. INTRODUCTION

2-2. This section of the manual contains information regarding installation and operation of the 2190A Digital Thermometer. It is recommended that the contents of this section be read and understood before any attempt is made to operate the instrument. Should any difficulties arise during operation, please contact your nearest Fluke Technical Service Center, or John Fluke Mfg. Co., Inc. P.O. Box C9090, Everett, WA 98206, Tel(206) 356-5400. A list of Technical Service Centers is located in Section 7 of this manual.

2-3. SHIPPING INFORMATION

2-4. The 2190A is packaged and shipped in a foam-packed container. Upon receipt of the instrument, a thorough inspection should be made to reveal any possible shipping damage. Special instructions for inspection and claims are included on the shipping carton.

2-5. If reshipment of the instrument is necessary, the original container should be used. If the original container is not available, a new one can be obtained from the John Fluke Mfg. Co., Inc. Please reference the instrument model number when requesting a new shipping container.

2-6. INPUT POWER

2-7. The 2190A will operate at any of four switch selected input line voltages. All operate at frequencies from 50 to 440 Hertz. A decal on the instrument rear panel defines the original setting of the line voltage selection switches. Refer to Section 4 of this manual for instruction on verifying or changing the input line voltage switch settings.

CAUTION

Before connecting the 2190A to the local ac line verify that the present setting of the instrument matches the local line voltage.

2-8. The rear panel ac input connector is a three-prong, U-ground connector which permits the instrument to be connected, via the power cord, to the applicable line voltage. The offset prong on this connector is connected to the 2190A transformer shield and should be connected through the power cord to a high quality earth ground. The rear panel external 12V dc connector accepts two wires from an external supply. The two receptacles are marked for polarity.

2-9. INSTALLATION

2-10. The 2190A and its individually packaged accessories are installed in PTI (Portable Test Instrument) cases. These cases are stackable, allowing the operator to fasten them together and transport a series of instruments as one unit. The maximum weight for the stacked units is forty pounds.

2-11. Prepare the 2190A for operation by plugging the input line power cord into the applicable power source or connecting the external input connector to an external 12V dc source.

2-11a. When interfacing your 2190A with a Fluke 2300A Scanner, use the following procedure to readjust the zero calibration of the 2190A:

1. Turn the 2190A and 2300A power off.

2. Remove the Thermocouple Input Assembly from the rear of the 2190A and ensure that the input terminals are open.

3. Place the eight position (labeled on the PCB) of S1 on and replace the Thermocouple Input Assembly into the 2190A.

4. Remove the Thermocouple Scanner Card (Option -002) from the 2300A Scanner, short the

input terminals for one of the channels and replace the Thermocouple Scanner Card into the 2300A.

5. Plug the 2300A Interface Option Cable into the 2190A Accessory Connector on the rear of the 2190A.

6. Turn the 2190A and 2300A power on.

7. Set the 2300A to the channel that was shorted in step 4.

8. Set the 2300A channel delay to 0.0.

9. Adjust the 2190A zero potentiometer (located on the 2190A front panel, behind the screw-locked cover) to obtain a 2190A display of 0.0.

10. Turn the 2190A and 2300A power off, remove the Thermocouple Input Assembly from the 2190A, move all switches of S1 to the off position and replace the Thermocouple Input Assembly into the 2190A.

NOTE

The 2190A zero will need to be readjusted if not being used with the 2300A. To readjust the 2190A zero, turn the 2190A power off, remove the Thermocouple Input Assembly, short the input terminals, repeat step 3, turn the 2190A power on, and repeat step 9.

2-12. OPERATING FEATURES

2-13. The location of the 2190A controls, indicators, and connectors are shown and described in Figure 2-1 and Table 2-1 respectively.

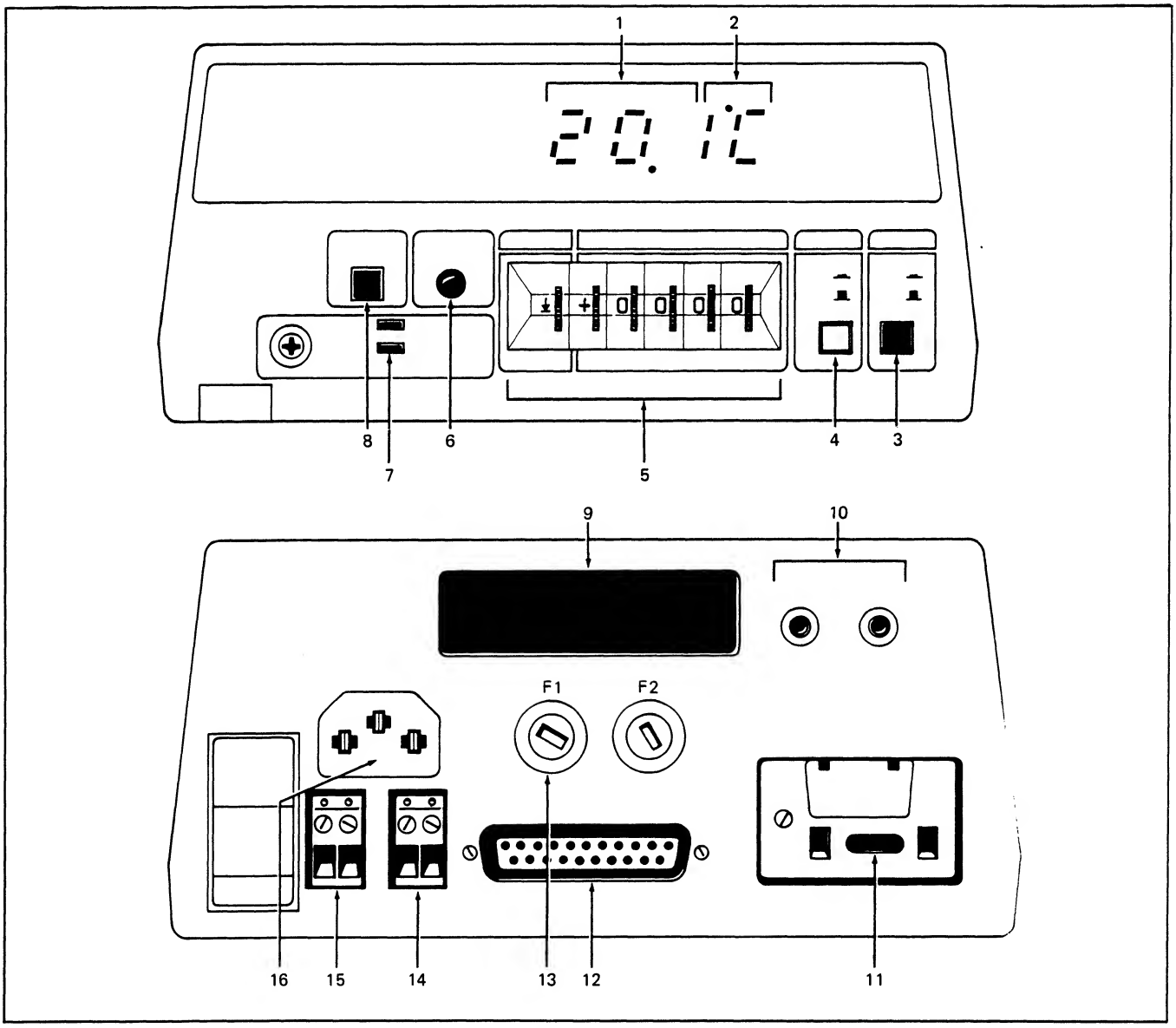


Figure 2-1. Controls and Indicators

Table 2-1. 2190A Controls, Indicators and Connectors

REF	NAME	FUNCTION
1	Digital Display	Displays a five digit readout of the measured input temperature. Leading zero suppression and a fixed decimal point are included. A minus sign is displayed for negative temperature measurements.
2	Temperature Scale Indicator	Displays the temperature scale represented by the digital display data; °C or °F.
3	Power Switch	Applies or removes power from the instrument.
4	SCALE	Selects the temperature scale for display; °C or °F.
5	LIMIT and FUNCTION	Used with the –006 Limit Option, if installed. Limit is a numeric set with thumbwheels to the value used by the selected function. FUNCTION, in combination with the LIMIT numeric sets an upper (>) or lower (≤) limit value which, if exceeded, will illuminate an indicator and close relay contacts accessible on the rear panel. The third function (△) causes the thermometer to display the difference between the actual reading and the value set on the LIMIT switches. The last two functions examine, and display, the maximum (⤒) or minimum (⤓) reading recorded in microcomputer since the last reset by the INITIALIZE MAX/MIN pushbutton switch.
6	LIMIT EXCEEDED	Part of the –006 Limits Option. Indicator illuminates when the preset limits have been exceeded.
7	CALIBRATION	Cover for calibration adjustments used in the calibration procedure.
8	INITIALIZE MAX/MIN	Part of the –006 Limits Option. Resets the accumulated maximum and minimum readings stored by the microcomputer.
9	DIGITAL OUTPUT	Connector for the ASCII coded data for the Output Unit, if 21X0A-002 is installed. Connector for the IEEE-488 if 21X0A-004 is installed (instead of 21X0A-002).
10	ANALOG OUTPUT	Banana jack connector for an Analog Output (1 mV per degree), if 21X0A-002 is installed. (Only used with 21X0A-002.)
11	INPUT CONNECTOR	Connection and access point for Thermocouple Input Module with isothermal block for thermocouple connection and selection.
12	ACCESSORY CONNECTOR	Cable connector for electrical connection from accessory units.
13	FUSES	Fuses for the input line power (F1) and the external 12V dc input (F2).
14	LIMITS	If the Limits feature is installed, provides an output terminal for a relay contact closure to signal when the set limits have been exceeded.
15	±12 VDC	Input terminals for the external 12V dc power source.
16	LINE VOLTAGE CONNECTOR	Input connector for the input line voltage.

2-14. OPERATING NOTES

2-15. The following paragraphs describe various conditions that could effect operation of the thermometer. The operator should familiarize himself with these conditions prior to operating the 2190A.

2-16. Option Information

2-17. Supplementary operating instructions are necessary when operating a 2190A equipped with one of the available options. Detailed information regarding the operation of each available option is given in Section 6 of this manual, Option and Accessory Information.

2-18. Fuse Replacement

2-19. The ac line input and external dc input are individually fuse protected. Both fuses are readily accessible on the outside of the rear panel. The ac line input fuse (F1) should be replaced with a 1/8A slo-blo fuse if either 100 or 120 volts has been selected as the input line voltage. Use a 1/16A replacement if 220 or 240 volts have been selected. The external dc input (F2) requires a 3/4A slo-blo fuse for a replacement.

2-20. Overload Thermocouple Indication

2-21. The front panel display, in addition to providing a measurement reading, provides an indication of an overload on the input thermocouple. When the measurement range of the selected thermocouple is exceeded the display flashes either the full-scale positive or full-scale negative reading, dependent on the polarity of the overload. The blinking indication does not necessarily indicate that the instrument is exposed to a damaging input condition.

2-22. Open Thermocouple Indication

2-23. If the thermocouple is open, or not connected to the input terminals, the display flashes the characters "O.C.". A signal from the rear panel relay contacts can also be obtained if the Limits Option (-006) is installed. To accomplish this, select either the positive (+OL) or negative (-OL) position on S4, located on the Main PCB (refer to Section 4 for access to the Main PCB), depending upon whether the Limits Option is set to greater than (>), or less than or equal (≤). If the limits are set for >, the S4 switch should be set to +OL for an open thermocouple to close the relay contacts for a signal. Conversely, for a signal with a ≤ limit, -OL should be selected.

2-24. Microcomputer Identification

2-25. The type of microcomputer installed in your instrument will determine the types of thermocouples that may be used. To determine the type of microcomputer you are using, connect the 2190A to line power and turn it on. For approximately the first ten seconds, the 2190A will display the microcomputer version, a decimal point, and the type of microcomputer in use. Example: A display reading of "9004.1" at turn on indicates that a type 1 of the 9004 version microcomputer is installed. Table 2-2 lists the microcomputer types with the thermocouples that they are programmed for.

2-26. OPERATION

2-27. Thermocouple Installation

2-28. Select the desired thermocouple range using the following procedure:

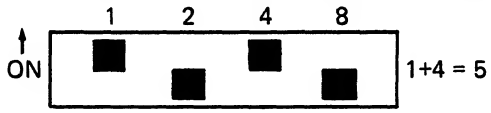
1. Remove the Thermocouple Input Module from the instrument through the access port on the rear panel, refer to Figure 2-2.

2. Connect the selected thermocouple to the input terminals on the isothermal block.

Table 2-2. Thermocouple Input Module Switch Settings.

DISPLAY AT TURN ON	MICROCOMPUTER TYPE	TYPE SELECT SWITCH SETTING (S1)									
		0	1	2	3	4	5	6	7	8*	9*
9004.1 or 9005.1	1	J	K	T	C			R		CAL	CAL
or 9005.2	2	J	K		E		S	R		CAL	CAL
or 9005.3	3	J**	K	T**		B		R		CAL	CAL

Example: To select a switch setting of 5, position the thermocouple type select switches as shown:



* In these positions the display will have a maximum range of 99 999 μV with 1 μV resolution.

** DIN standard

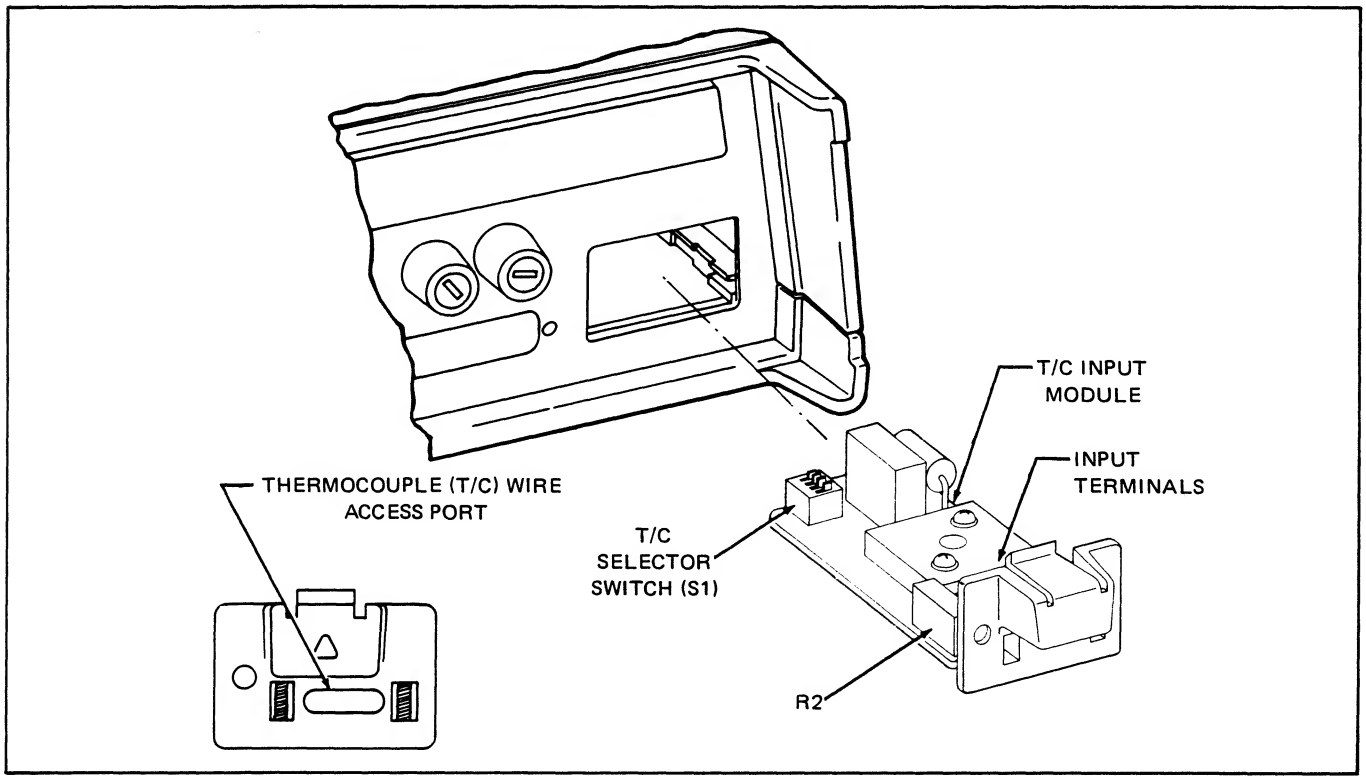


Figure 2-2. Thermocouple PCB Access

3. Set the thermocouple selector switch to the setting shown in Table 2-2 and on the pcb beside the isothermal block, for the thermocouple installed.

4. Connect the Thermocouple Input Module to the instrument Main PCB through the access port on the rear panel.

5. Verify that the instrument has been calibrated for the thermocouple in use. See Section 4 "Thermocouple Input Calibration" for more information.

2-29. Thermometer Operation

2-30. Operate the 2190A Digital Thermometer using the following procedure:

1. Verify that the instrument has the correct thermocouple connected, or install the desired thermocouple using the procedure previously given in this section.

2. Connect the input line cord to the applicable power source.

3. Select the temperature scale desired for display with the front panel SCALE switch (in for °C and out for °F).

NOTE

If Option -006 is installed the FUNCTION thumbwheels must be set for Limits (> or ≤) for a direct temperature reading.

4. Select POWER ON.

NOTE

Refer to Section 6 of this manual or applicable accessory manuals, for instructions on the operation of any installed options or connected accessories.

5. Expose the thermocouple probe to an unknown temperature or the temperature to be monitored, within the thermocouple's specified range (see Specifications in Section 1).

6. The probe temperature, in the scale selected, is displayed on the front panel.

2-31. Voltage Measurements

2-32. The 2190A may be used to measure positive or negative voltages up to 99.999 mV with 1 μV resolution. When using the 2190A to measure voltages, the temperature units (°C, °F) are to be ignored. Since the decimal point will be fixed, ignore it and read the display in μV. Example: 99 mV input = display of "9900.0" °F or °C. Use the following steps to measure voltages with your 2190A.

1. Remove the 2190A's Thermocouple Input Module, refer to Figure 2-2.

2. On the Thermocouple Input Module, set select switches to position #8 or #9 (refer to Table 2-2 for switch selection, and Table 2-3 for switch functions). Replace the Thermocouple Input Module.

NOTE

For the following steps the source resistance must be kept below 2 kΩ or a 0.1 μF capacitor must be placed across TC+, TC–.

3. Connect the unknown voltage to TC+ and TC–.

4. Turn the 2190A on, display will now read in μV units.

Table 2-3. T/C Input Module Switch Functions

SWITCH	SWITCH POSITION	SWITCH FUNCTIONS
S1	0 - 6	Programs the microcomputer (μc) for each T/C probe type (see Table 2-2).
	7	Not Used
	8, 9	"CAL", programs the μc to read μV (bypasses the linearization program).

Section 3
Theory of Operation

3-1. INTRODUCTION

3-2. This section of the manual contains an overall functional description, followed by a brief circuit analysis of the 2190A Digital Thermometer. Simplified circuit diagrams are provided, as necessary, to supplement the text. Detailed schematics are given in Section 8 of this manual.

3-3. OVERALL FUNCTIONAL DESCRIPTION

3-4. The Model 2190A Digital Thermometer, shown in Figure 3-1, is a 5-digit microcomputer controlled thermocouple thermometer capable of resolving 0.1°C or 0.1°F over temperature range of -252° to 2471°C or -486° to 4480°F. It features a reference-junction compensator (eliminating the need for an ice bath reference-junction), dual-slope A/D conversion technique, microcomputer control logic, and a 5-digit display with temperature scale indicator.

3-5. In operation, the 2190A executes a continuous series of measurement cycles to update the temperature display. The measurement cycle is controlled entirely by the microcomputer and includes three major subcycles; the Auto-Zero, Integrate, and Read periods. Each subcycle controls the operation of the analog section of a dual-slope integrator, which in turn, generates a compare output, which is used by the microcomputer to generate the proper control signals. (In addition to these major subcycles, a recovery signal is applied at the end of the read period to assist the Auto-Zero period.)

3-6. The configuration of the analog section during each phase of the measurement cycle, is established by the condition of microcomputer controlled FET switches. The measurement cycle begins with the Auto-Zero period. During this period, the input to the Buffer Amplifier is connected to ground through an FET switch and the accumulated dc offset voltages present in the analog section are sampled and held by the Auto-Zero capacitor. This voltage is used later in the measurement cycle to cancel measurement errors introduced by offset voltages present in the analog circuitry. As a result, the final measurement is proportional to the thermocouple probe output voltage and does not include offset errors.

3-7. During the Integrate period, the thermocouple input voltages (probe voltage and input terminal voltages) are applied to the integrator and the algebraic sum of these voltages is integrated over a 100 ms period. At the end of this period the thermocouple input voltages are removed from the integrator and the Read period is started.

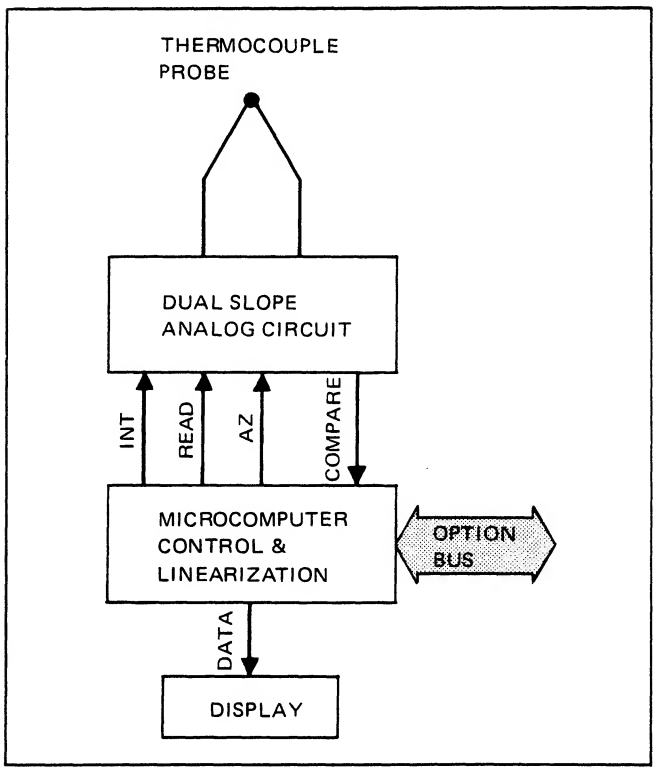


Figure 3-1. 2190A Simplified Block Diagram

3-8. A reference voltage is applied to the integrator during the Read period, causing the integrator capacitor to be discharged at a linear rate. When the integrator output reaches the voltage stored on the Auto-Zero capacitor a compare signal is generated to end the Read period. The duration of the Read period is translated by the microcomputer to provide a digital indication proportional to the thermocouple probe voltage.

3-9. To compensate for the error voltage present on the input terminals, the microcomputer configures the analog portion to do a complete conversion cycle on the reference-junction voltage every 11th read cycle. This voltage is generated by a transistor which is at the same temperature as the input terminals. The microcomputer uses the number generated during the Read period to compensate the input voltage and display the actual probe temperature.

3-10. CIRCUIT ANALYSIS

3-11. Circuit analysis of the 2190A is discussed in two sections; digital and analog. The digital section is covered first and particular attention is paid to the control it exercises on the analog section. The analysis of the analog section covers the analog measurement circuitry and the power supply.

3-12. Digital Section

3-13. The digital section of the 2190A consists of a single-chip microcomputer (U4), which has a self-contained, programmed, read only memory; a hex CMOS open drain buffer (U3) and an LED display. Its function is to convert the non-linear thermocouple probe voltage, as measured by the analog section, into a linear digital display, provide the necessary control signals to the analog section and to provide control for all accessories on an accessory bus. The 2190A LED display provides a direct reading of the probe temperature in °C or °F.

3-14. The microcomputer contains all 2190A program, control logic, and linearizing capability and provides the display with all signals necessary to update the display. The linearization of the non-linear input signal is accomplished by selecting one-of-several programs which compute the correct temperature using a 4th-order, curve-fit approximation of the probe output. The operating program is selected to match a particular thermocouple type and is enabled by the numeric setting corresponding to the thermocouple type in use. The rotary switch is located on the thermocouple input assembly next to a table showing the switch setting applicable to the thermocouple type in use.

3-15. Measurement data is continuously strobed out of the microcomputer in decoded-seven-segment, character-serial format and sent to the LED display. With an overload condition the display flashes on and off. An "O.C." display indicates an open thermocouple probe condition.

3-16. The basic measurement cycle shown in Figure 3-2, consists of three major subcycles; a 100 ms minimum Auto-Zero period, a 100 ms Integrate period, and a variable Read period. The total measurement cycle time consists of 300 ms; 100 ms to integrate, up to 100 ms to the Read period, and the remaining time to the Auto-Zero period. (Auto-Zero time will vary from 100 to 200 ms.) To accomodate settling times in the analog section a (Δ) 2, (1 ms nominal) hold signal is inserted at the beginning and at the end of the Integrate period.

3-17. Analog Section

3-18. ANALOG MEASUREMENT CIRCUIT

3-19. The analog circuit is shown in simplified form in Figure 3-3. It consists of a thermocouple input circuit, a reference-junction compensator, a voltage reference, a buffer amplifier, an integrator, a gain stage, a comparator, and a combination of FET switches. The switches are shown in their open state and are closed by the measurement cycle commands generated by the microcomputer.

3-20. The Thermocouple Input circuit consists of an R-C filter and a pair of voltage protection diodes. The difference between the thermocouple probe voltage and the input terminal voltage is passed through the filter and appears at FET switch Q15. The R-C filter increases the normal mode rejection capability of the 2190A.

3-21. The reference-junction compensator consists of an isothermal block, a pair of screw type input terminals and a transistor temperature sensor, (all on the Thermocouple Input Assembly). The isothermal block maintains a negligible temperature differential between the input terminals and the temperature sensing transistor. Thermocouple voltages introduced by the dissimilar metals at the input terminals vary as the isothermal block adjusts to ambient temperature. Temperature changes are sensed by the forward biased transistor to produce a correction voltage which is read by the analog measurement circuitry every eleven cycles. The reading is saved by the microcomputer and is used to compensate for the error voltages present at the input terminals. Predictable characteristics of a forward-biased P-N junction allow the reference-junction compensator to function over a wide temperature range. This correction voltage occurs at FET switch Q17.

3-22. The voltage reference consists of a thin-film resistor network supplied by an accurate 6.2V dc reference voltage. The divider is set to provide 100 mV and 200 mV. These voltages appear at FET switches Q12 and Q13, respectively.

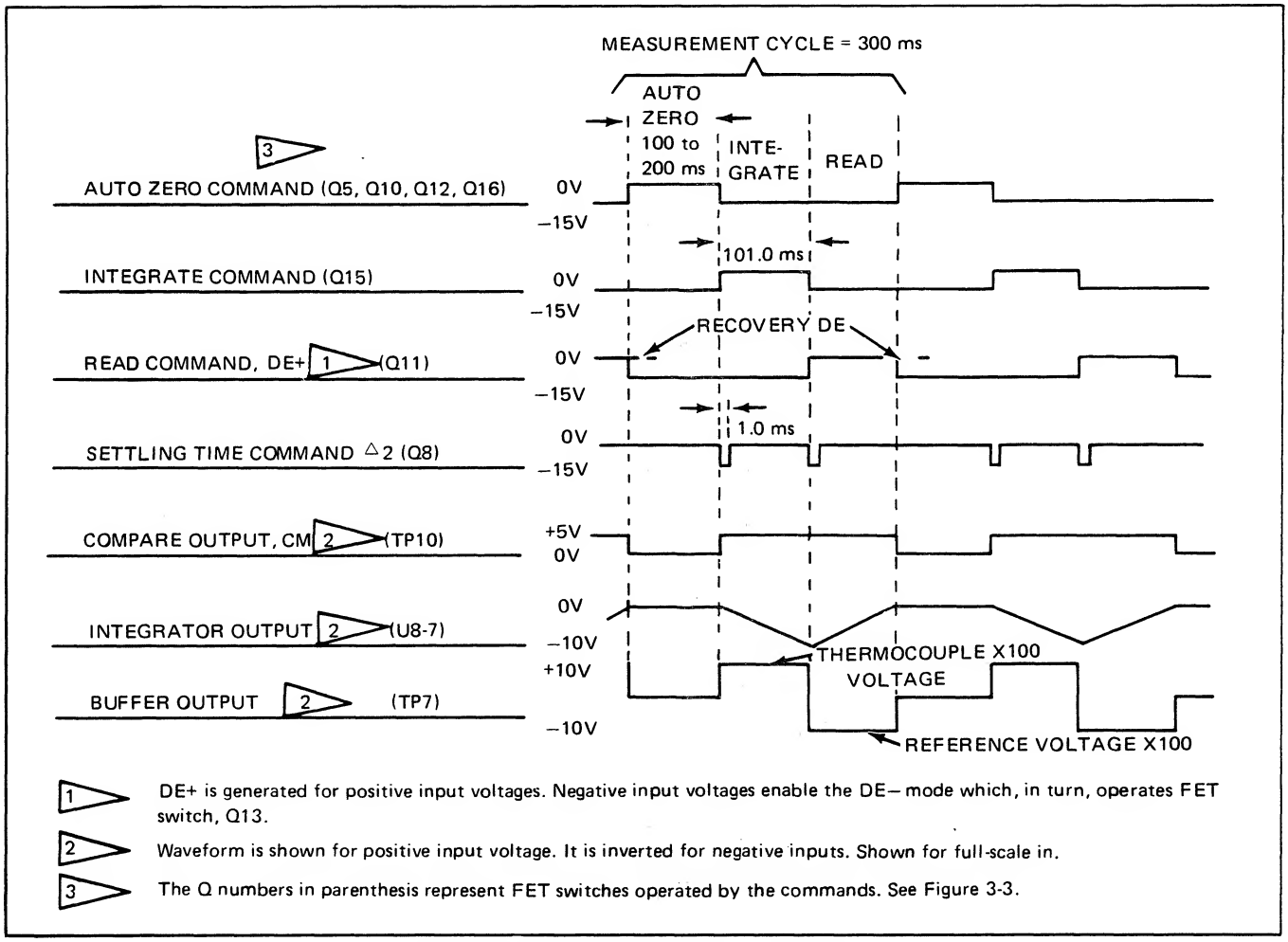


Figure 3-2. Measurement Cycle Waveforms

3-23. The Buffer, Integrator, Gain Stage, and Comparator Amplifiers combine to perform the analog functions of the Integrate, Read, and Auto-Zero periods. The Buffer is used to provide integrator inputs during all three periods. The Integrator integrates the Buffer output voltage during the Integrate and Read periods and, in combination with the Gain Stage, functions as a closed-loop amplifier during the Auto-Zero period.

3-24. During the first phase of each measurement cycle, the analog section goes through an Auto-Zero period. During this time, four auto-zero switches (Q12, Q16, Q6, and Q10) are closed by the Auto-Zero command from the microcomputer. Two of the switches (Q12 and Q16) charge the reference capacitor to 100 mV. Switch Q16 also zeroes the input to the buffer amplifier. The third switch, Q6 connects the Integrator and Gain Stage into a closed-loop configuration and allows the auto-zero capacitor (C10) to charge to a value which is proportional to the algebraic sum of all the offset voltages present in the Buffer, Integrator, and Gain Stage. At the end of the Auto-Zero period, switches Q12, Q16, Q6 and Q10 are opened. The VREF capacitor and the auto-zero capacitor retain their charge for use later in the measurement cycle.

3-25. The Integrate period (see Figure 3-2) starts on the leading edge of the integrate command from the microcomputer; switch Q15 is closed and switch Q8 is opened. The thermocouple input voltage is applied through switch Q15 to the buffer input. After a 1 ms settling period, switch Q8 closes and the buffer output is applied to the Integrator for 100 ms. As the integrator capacitor charges, the Integrator drives the comparator (through the Gain Stage) to either 0 or +5V dc to indicate the polarity of the thermocouple input voltage, negative or positive, respectively. At the end of the Integrate period, the integrate capacitor is charged to a level and polarity which are proportional to the thermocouple input voltage and switches Q15 and Q8 return to the open state.

3-26. The Read period starts at the end of the Integrate period and one-of-two Read modes is enabled depending upon the input polarity sensed by the comparator during the Integrate period. If a positive input is sensed, a positive Read mode is enabled. Similarly, a negative Read mode is enabled when a negative input is sensed.

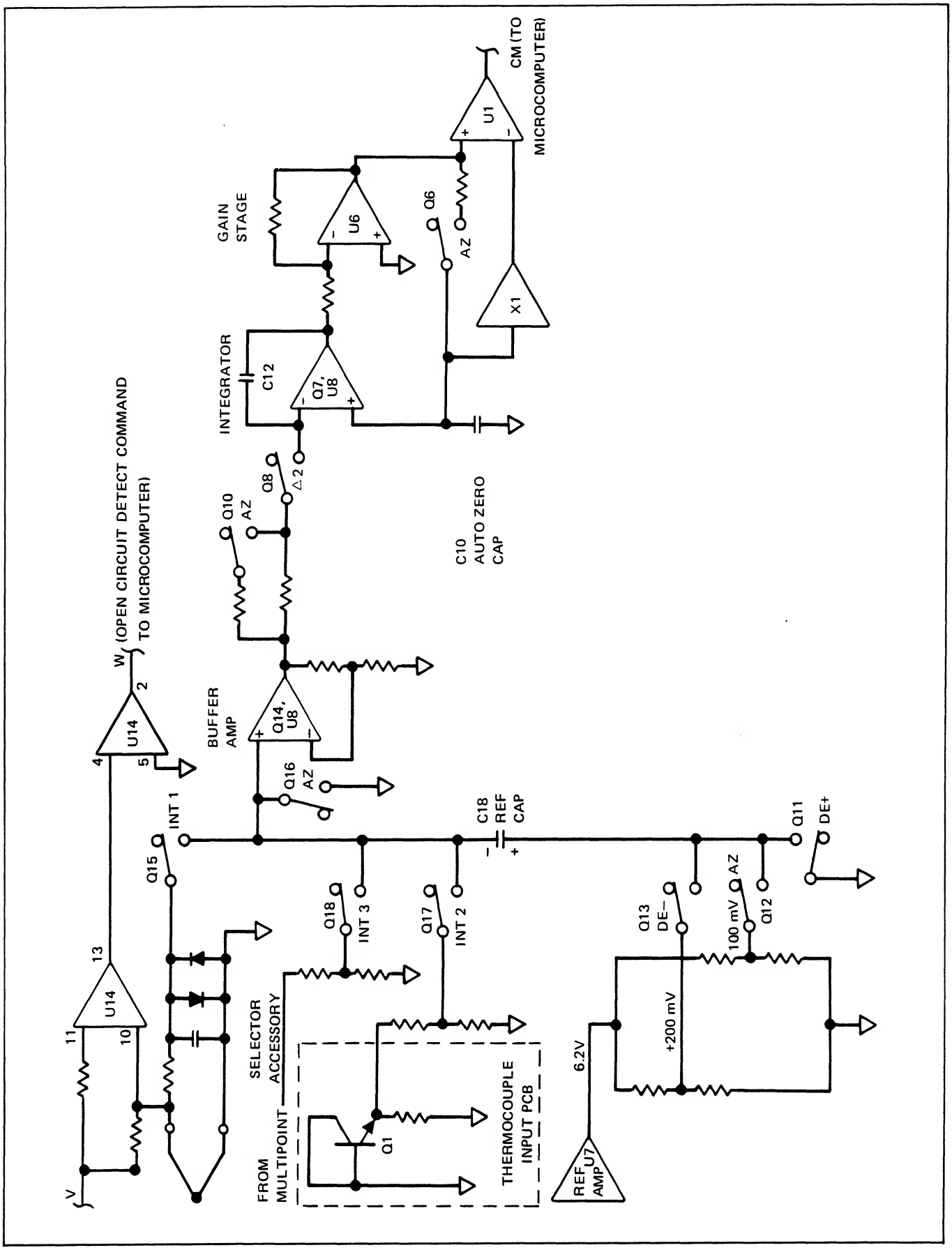


Figure 3-3. Simplified Schematic — Analog Section

3-27. If the positive Read mode is commanded, FET switch Q11 is closed. This grounds the positive end of the VREF capacitor which effectively applies -100 mV to the input of the buffer.

3-28. If the negative Read mode is commanded, switch Q13 is closed connecting the positive end of the VREF capacitor to +200 mV. Therefore, the voltage applied to the buffer is the algebraic sum of 200 mV and the voltage across the reference capacitor. This effectively applies +100 mV to the input of the buffer.

3-29. After a 1 ms settling time, switch Q8 closes and the buffer output voltage is applied to the integrator input, causing the integrator capacitor to discharge at a linear rate determined by the reference voltage. The discharge continues until the integrator voltage reaches the comparator trip point, which is referenced to the voltage on the auto-zero capacitor. When this level is reached the comparator changes state, commanding the microcomputer to terminate the Read period. To facilitate Auto-Zero, the microcomputer then calls a reference voltage opposite in polarity to the one previously used. When the integrator again reaches the trip point, the microcomputer immediately begins the Auto-Zero period.

3-30. Offset voltages present during the Integrate and Read periods are cancelled by offset voltages that were sampled and held during the Auto-Zero period. However, during conversion within the microcomputer, the temperature corresponding to the reference-junction voltage is added to the measurement data and, as a result, the displayed temperature is equal to the thermocouple probe temperature.

3-31. O.C. DETECTOR

3-32. The open thermocouple detector (U14 and its associated circuitry) on the thermometer is used to determine whether or not the impedance at the input terminals exceeds a predetermined level. It therefore provides an indication of a broken or faulty thermocouple. A square wave is applied to the input of the thermometer and its magnitude is compared to a reference square wave. If the reference is exceeded, an open circuit condition is detected. This occurs at a nominal 2 kΩ.

3-33. POWER SUPPLY

3-34. The 2190A power supply consists of a DC-to-DC Converter and voltage regulating circuitry. AC inputs are made via the input power cord, line fuse, and power transformer/rectifier. External +12 volt dc inputs can also be made directly to the DC-to-DC Converter via line TB1 (see Main PCB schematic, Section 8). The function of the power supply is to provide +5, +15, and -15 dc operation voltages for the 2190A circuitry. The power supply can be driven from AC line or 12V dc external source. The DC-to-DC conversion and voltage regulation is accomplished using conventional power supply design techniques.

Section 4
Maintenance

WARNING

THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS, UNLESS YOU ARE QUALIFIED TO DO SO.

4-1. INTRODUCTION

4-2. This section of the manual provides information about warranty, factory service, maintenance, performance testing, routine recalibration, and recalibration after repair. The performance test is recommended when the instrument is received and later as a preventive maintenance tool or for testing after repair. The test verifies performance at several temperatures within the range of a given thermocouple type. Specifications are provided both for annual and for a more precise 90-day performance-testing cycle.

4-3. SERVICE INFORMATION

4-4. The instrument is warranted for a period of 1-year upon delivery to the original purchaser. The WARRANTY is located on the back of the title page located in the front of this manual.

4-5. Factory authorized calibration and service for each Fluke product is available at various worldwide locations. A complete list of these service centers is included in Section 7 of this manual. If requested, an estimate will be provided to the customer before any work is begun on instruments that are beyond the warranty period.

4-6. GENERAL MAINTENANCE

4-7. Instrument Disassembly

4-8. Removal of the instrument from its case is necessary only for maintenance. Routine calibration can be done without such removal. Disassemble the thermometer using the following procedure:

1. Remove the Thermocouple Input PCB Assembly through its access port in the rear panel.

2. Remove the four screws on the bottom of the instrument that secure the two halves together and lift the top cover free.

3. Remove the Output Option, if installed and required, by removing the three screws connecting it to the Main PCB, disconnecting the interconnect cables at J1 and J3, and lifting the Option PCB clear.

4. Remove the screw securing the center of the Main PCB to the bottom portion of the case.

5. Lift the Main PCB, complete with front and rear panels, clear of the case.

6. Remove the front panel, if required, by disconnecting the guard screw at the lower right corner; disconnecting the front panel interconnect cable at J6; disconnecting, if installed, the Limits Option interconnect cable at J4, and moving the front panel forward.

7. Remove the rear panel, if required, by removing the three screws attaching it to the Main PCB; disconnecting the wires from the input line power connector; unsoldering the wires from two fuse holders and moving the rear panel free.

8. Perform reassembly in the reverse order.

4-9. Input Line Power Selection

4-10. Input line power voltage is selected by positioning the slot on two switches. Figure 4-1, shows the switches on the right edge of the Main PCB set for 120 volt ac operation. Table 4-1, lists the switch settings for other line voltages available.

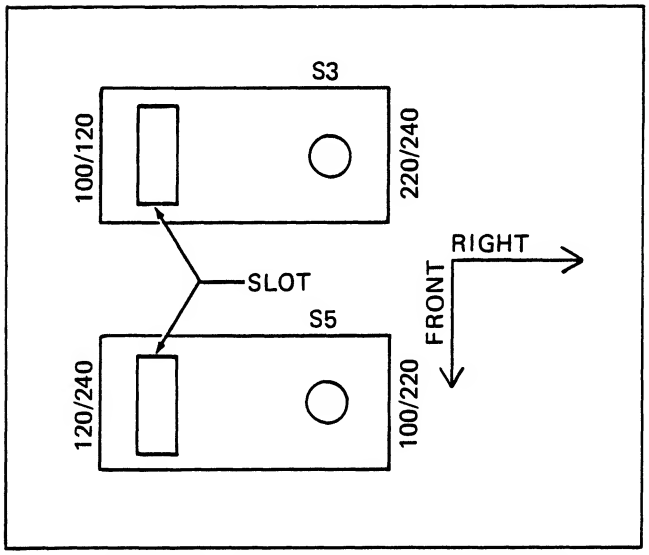


Figure 4-1. Line Voltage Selection Switches

Table 4-1. Line Voltage Selection Switches Positioning

VOLTAGE	S3 SLOT (REAR SW)	S5 SLOT (FRONT SW)
100	Left	Right
120	Left	Left
220	Right	Right
240	Right	Left

4-11. Cleaning

4-12. Clean the instrument periodically to remove dust, grease, and other contamination. Use the following procedure:

CAUTION

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. They will react with plastic materials used in the manufacture of the instrument.

1. Clean the front panel and case with a soft cloth dampened with a mild solution of detergent and water.

2. Clean the surface of the pcb using clean, dry air at low pressure (≤20 psi). If grease is encountered, spray with Freon T.F. Degreaser or anhydrous alcohol and remove grime with clean, dry air at low pressure.

4-13. Fuse Replacement

WARNING

DISCONNECT THE UNIT FROM LINE POWER BEFORE ATTEMPTING FUSE REPLACEMENT.

4-14. The 2190A has two fuses, both accessible on the rear panel. F1 is for the input line power and should be replaced, when necessary, with a 1/8A MDL (slo-blo) fuse when the input line power selected is 100V or 120V. When the input power selected is 220V or 240V, F1 should be replaced with a 1/16A MDL fuse. F2 is for the 12V dc external power and requires 3/4A MDL fuse.

4-15. Service Tools

4-16. No special tools are required for maintenance or repair.

4-17. PERFORMANCE TEST

4-18. The performance tests listed here (Ambient Temperature or Ice Bath Test) perform the same function, specifically, verifying instrument performance to its specifications. Either test may be used for initial acceptance, verifying calibration, or as an aid in troubleshooting. Both tests need not be performed. If the thermometer fails to meet specifications in either performance test, the calibration adjustment procedure or troubleshooting should be performed, as determined by qualified personnel.

4-19. Table 4-2, lists the equipment required for the performance test and calibration adjustment procedure. If the recommended model of test equipment is not

available, a substitute that meets the minimum use specifications may be used. The test should be conducted with an ambient temperature of 25 ±2°C (77.0 ±3.6°F).

4-20. Ambient Temperature Test

4-21 Use the following procedure to test the instrument at ambient temperature:

1. Turn the POWER switch OFF and remove the line power cord from the line voltage source.

2. Select the switch position on the Thermocouple Input Module corresponding to the microcomputer and thermocouple type in use, see Table 2-2.

3. Connect the equipment as shown in Figure 4-2.

Table 4-2. Test Equipment Requirements

TEST EQUIPMENT	MINIMUM USE SPECIFICATIONS	RECOMMENDED MODEL
Thermocouple Wires	Type K preferred	Omega or manufacture specification
Mercury Thermometer (either °C or °F)	0.02° C resolution 0.05°F resolution	Princo Model ASTM56C Princo Model ASTM56F
Dewar Flask/Cap	1-pint capacity	Thermos
DC Voltage Calibrator	Output Voltage 0 to 10V Accuracy: 0.002% Resolution: 100 uV	Fluke Model 343A
Voltage Divider 100:1 Kelvin-Varley Divider (Shunt output with 1 uF capacitor)	Ratio: 0.005%	Fluke Y2022 or Fluke 720A or Fluke 750A
Variable Line-Voltage Transformer	100, 115, 230V ac, as required, ±10%	General Radio VARIAC W5HM
Decade Resistor	Accuracy: 1% Ranges: 1k, 10k, and 100k	General Radio 1434
Voltmeter	Resolution: 100 μV Accuracy: .008%	Fluke 8800A

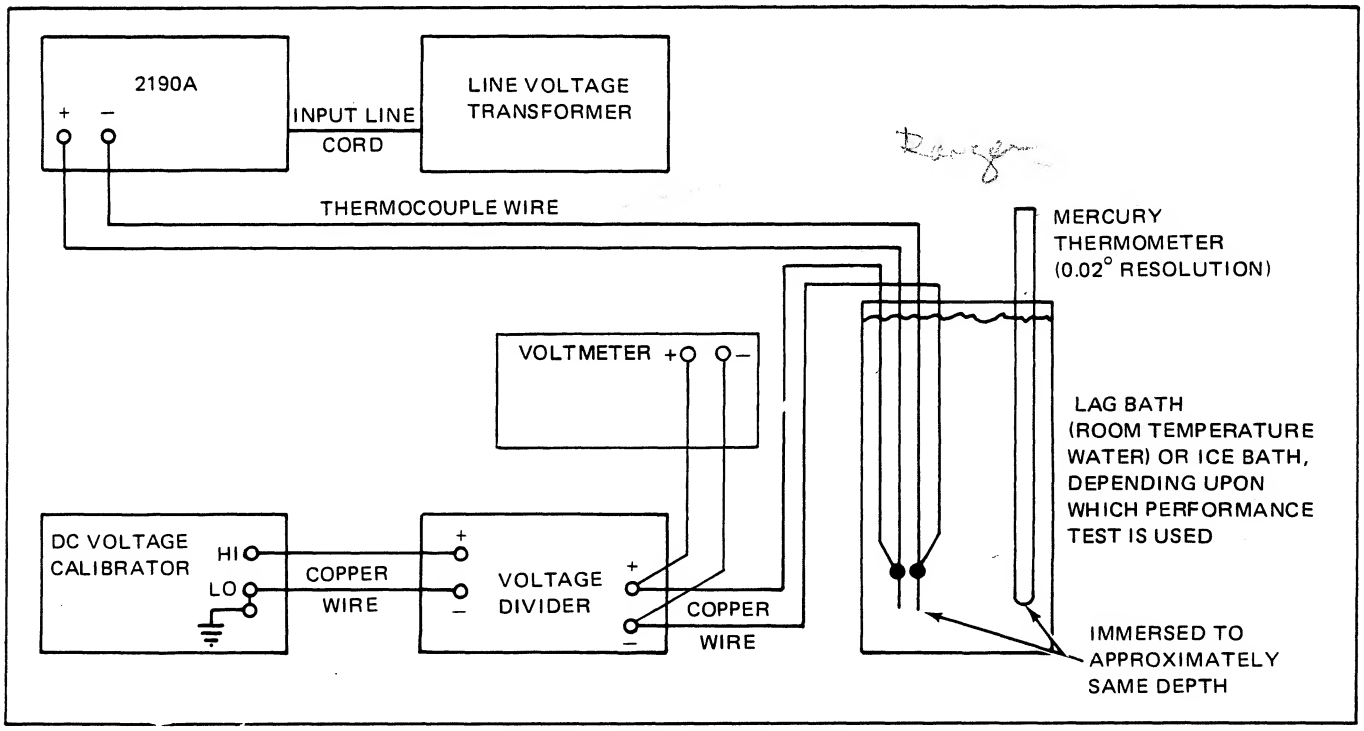


Figure 4-2. Equipment Connections

NOTE

Whenever the 720A or 750A is used as the divider a 1 μF capacitor must be placed across its output terminals, otherwise an open thermocouple condition will result.

4. Verify that the POWER switch is OFF, then adjust the line voltage transformer for the nominal input line voltage.

5. Turn the POWER switch ON.

6. Allow the 2190A to stabilize (at least 5 minutes).

7. Select the temperature scale (°C or °F) on the 2190A to agree with the temperature scale of the mercury thermometer in the lag bath.

8. Read the temperature of the mercury thermometer and find the corresponding mV reading to this temperature (refer to the Thermocouple Reference Tables in Section 7B of this manual). Interpolation may be used as necessary.

9. Algebraically subtract the mV reading found in step 8 from the first value found under the "Divider Output mV" column of Table 4-3, for the microcomputer and corresponding thermocouple type in use.

10. Obtain a divider output equal to the result found in step 9 by adjusting the calibrator, or if using the 720A or 750A, adjust the divider.

11. Verify that the 2190A reads the value listed in Table 4-3, within the limits specified (90-day or 1-year as required).

12. Repeat steps 8, 9, 10, and 11 for the remaining voltages in the "Divider Output mV" column.

13. Set the line voltage transformer for line voltage minus ten percent and repeat the test for one thermocouple type.

14. Set the line voltage transformer for line voltage plus ten percent and repeat the test for one thermocouple type.

15. Set the line voltage transformer for the input line voltage.

16. Disconnect the thermocouple from the input terminals.

17. This completes the performance test.

4-22. Ice Bath Construction

4-23. To construct an ice point bath, use the following procedure:

1. Prepare a thermos by drilling two holes in its cap to accept the thermometer and thermocouple wires or use a standard laboratory cork.

2. Fill the thermos with shaved or crushed ice made from distilled water.

3. Fill the thermos with enough distilled water so that the ice becomes slush, but not enough to float the ice.

NOTE

As the ice melts, siphon off the excess water and add more ice. Allow approximately 5 to 10 minutes for the water to drop back to the freezing point.

4. Replace the thermos cap or cork and insert thermocouple wires and thermometer as shown in Figure 4-2.

Table 4-3. Performance Test Values

THERMOCOUPLE TYPE	DIVIDER OUTPUT mV	°F (2190A DISPLAY)		°C (2190A DISPLAY)	
		90 DAY	1 YEAR	90 DAY	1 YEAR
MICROCOMPUTER TYPE #1					
J	−5.553	−190 ± 0.2	−190 ± 0.2	−123.3 ± 0.2	−123.3 ± 0.2
	−2.483	−60.0 ± 0.2	−60.0 ± 0.2	−51.1 ± 0.2	−51.1 ± 0.2
	23.317	800.0 ± 0.2	800.0 ± 0.3	426.7 ± 0.2	426.7 ± 0.2
K	−4.230	−190 ± 0.3	−190 ± 0.3	−123.3 ± 0.2	−123.3 ± 0.2
	−1.929	−60 ± 0.3	−60 ± 0.3	−51.1 ± 0.2	−51.1 ± 0.2
	26.975	1200 ± 0.5	1200 ± 0.5	648.9 ± 0.3	648.9 ± 0.3
	52.939	2400 ± 0.7	2400 ± 0.7	1315.6 ± 0.4	1315.6 ± 0.4

Table 4-3. Performance Test Values (cont)

THERMOCOUPLE TYPE	DIVIDER OUTPUT mV	°F (2190A DISPLAY)		°C (2190A DISPLAY)	
		90 DAY	1 YEAR	90 DAY	1 YEAR
MICROCOMPUTER TYPE #1 (cont)					
T	−6.105	−400 ± 0.3	−400 ± 0.3	204.4 ± 0.2	204.4 ± 0.2
	−4.009	−190 ± 0.3	−190 ± 0.3	−123.3 ± 0.2	−123.3 ± 0.2
	8.062	350 ± 0.3	350 ± 0.3	176.7 ± 0.2	176.7 ± 0.2
	20.458	740 ± 0.4	740 ± 0.4	393.3 ± 0.2	393.3 ± 0.2
C	0.522	100 ± 0.3	100 ± 0.3	37.8 ± 0.2	37.8 ± 0.2
	19.947	2000 ± 0.6	2000 ± 0.7	1093.3 ± 0.4	1093.3 ± 0.4
	36.539	4100 ± 1.1	4100 ± 1.2	2260.0 ± 0.6	2260.0 ± 0.6
R	1.508	400 ± 0.4	400 ± 0.4	204.4 ± 0.3	204.4 ± 0.3
	8.141	1500 ± 0.6	1500 ± 0.7	815.6 ± 0.4	815.6 ± 0.2
	20.275	3100 ± 0.9	3100 ± 1.0	1704.4 ± 0.6	1704.4 ± 0.6
MICROCOMPUTER TYPE #2					
J	−5.553	−190 ± 0.2	−190 ± 0.2	−123.3 ± 0.2	−123.3 ± 0.2
	−2.483	−60.0 ± 0.2	−60.0 ± 0.2	−51.1 ± 0.2	−51.1 ± 0.2
	23.317	800.0 ± 0.2	800.0 ± 0.3	426.7 ± 0.2	426.7 ± 0.2
K	−4.230	−190 ± 0.3	−190 ± 0.3	−123.3 ± 0.2	−123.3 ± 0.2
	−1.929	−60 ± 0.3	−60 ± 0.3	−51.1 ± 0.2	−51.1 ± 0.2
	26.975	1200 ± 0.5	1200 ± 0.5	648.9 ± 0.3	648.9 ± 0.3
	52.939	2400 ± 0.7	2400 ± 0.7	1315.6 ± 0.4	1315.6 ± 0.4
E	−9.604	−400 ± 0.3	−400 ± 0.3	204.4 ± 0.2	204.4 ± 0.2
	−6.471	−200 ± 0.3	−200 ± 0.3	−128.9 ± 0.2	−128.9 ± 0.2
	35.562	900 ± 0.3	900 ± 0.4	482.2 ± 0.2	482.2 ± 0.2
	75.024	1800 ± 0.6	1800 ± 0.6	982.2 ± 0.3	982.2 ± 0.3
R	1.508	400 ± 0.4	400 ± 0.4	204.4 ± 0.3	204.4 ± 0.3
	8.141	1500 ± 0.6	1500 ± 0.7	815.6 ± 0.4	815.6 ± 0.2
	20.275	3100 ± 0.9	3100 ± 1.0	1704.4 ± 0.6	1704.4 ± 0.6
S	1.962	500 ± 0.3	500 ± 0.4	260.0 ± 0.2	260.0 ± 0.2
	7.514	1500 ± 0.5	1500 ± 0.6	815.6 ± 0.3	815.6 ± 0.3
	17.762	3064 ± 0.8	3064 ± 0.9	1684.4 ± 0.5	1684.4 ± 0.5
MICROCOMPUTER TYPE #3					
JDIN*	−4.33	−130.0 ±0.3	−130.0 ±0.3	−90.0 ±0.2	−90.0 ±0.2
	10.95	392.0 ±0.3	392.0 ±0.4	200.0 ±0.2	200.0 ±0.2
	42.92	1382.0 ±0.5	1382.0 ±0.5	750.0 ±0.3	750.0 ±0.3
K	−1.527	−40.0 ±0.3	−40.0 ±0.3	−40.0 ±0.2	−40.0 ±0.2
	26.975	1200.0 ±0.5	1200.0 ±0.5	648.9 ±0.3	648.9 ±0.3
	52.939	2400.0 ±0.7	2400.0 ±0.7	1315.6 ±0.4	1315.6 ±0.4
TDIN*	−5.510	−310.0 ±0.3	−310.0 ±0.3	−190.0 ±0.2	−190.0 ±0.2
	2.480	140.0 ±0.3	140.0 ±0.3	60.0 ±0.2	60.0 ±0.2
	20.380	734.0 ±0.4	734.0 ±0.4	390.0 ±0.2	390.0 ±0.2
B	0.891	797.0 ±0.5	797.0 ±0.5	425.0 ±0.3	425.0 ±0.3
	6.783	2192.0 ±0.7	2192.0 ±0.8	1200.0 ±0.4	1200.0 ±0.4
	13.699	3290.0 ±0.9	3290.0 ±1.0	1810.0 ±0.5	1810.0 ±0.5
R	1.508	400.0 ±0.4	400.0 ±0.4	204.4 ± 0.3	204.4 ± 0.3
	8.141	1500.0 ±0.6	1500.0 ±0.6	815.6 ±0.4	815.6 ±0.4
	20.215	3062 ± 0.9	3062 ± 0.9	1700 ± 0.6	1700 ± 0.6

*European Standard

4-24. Ice Bath Test

4-25. Use the following procedure to test the 2190A using an ice point bath:

1. Repeat steps 1 through 7 of ambient temperature test; verify that the temperature of the water is at the freezing point.

2. Using Table 4-3 (for the corresponding microcomputer and thermocouple type) obtain a divider output equal to the first value of the "Divider Output mV" column and verify that the 2190A reads within the limits specified, 90-day or 1-year.

3. Repeat step 2 for the remaining voltages in the "Divider Output mV" column.

4. Repeat steps 13 through 17 of ambient temperature test.

4-26. CALIBRATION ADJUSTMENT PROCEDURE

4-27. The thermometer should be calibrated at either 90-day or annual periods, depending upon the accuracy desired, and any time that repairs are made to the instrument. Either scale can be verified by executing the performance test previously given. The microcomputer can also be changed without effecting the calibration of the instrument.

4-28. Equipment Preparation

4-29. Prepare the equipment for calibration using the following procedure:

1. Remove the top cover from the instrument.

2. Select switch setting of 9 (CAL) on the Thermocouple Input Module to disable the reference-junction circuitry (see Table 2-2).

3. Connect the equipment as shown in Figure 4-3. Refer to Table 4-2 for the applicable test equipment models.

NOTE

Insure the instrument warm-up period has been sufficient to reach rated accuracy (at least 5 minutes).

4. Select the desired temperature scale.

NOTE

If the Limits Option is installed select the LIMITS (≤ or >) function.

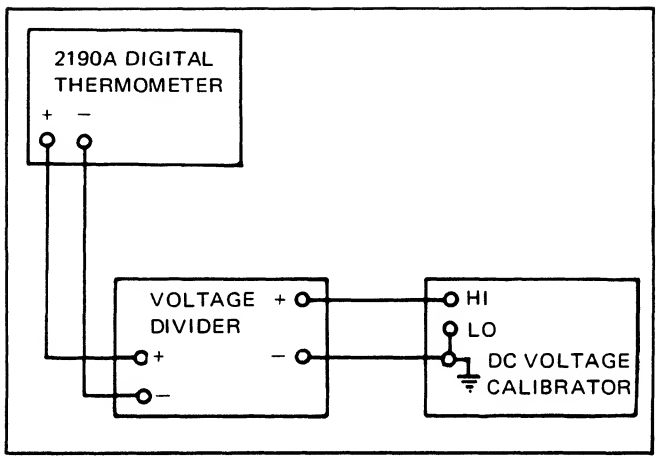


Figure 4-3. Calibration Adjustment Connections

4-30. Zero Adjustment

4-31. Perform zero adjustment using the following procedure:

1. Select a thermometer input, from the voltage divider, of 10.2 μV dc.

2. Record the thermometer display.

3. Reverse the polarity of the input by reversing the polarity of the calibrator output.

4. Record the thermometer display.

5. Adjust ZERO (R31) through the front panel access port and repeat steps 1 through 4 as required to obtain the same value in both step 2 and 4.

6. Adjust R14 for a thermometer display of 1.0 of the same polarity as the input.

7. Connect a test DMM between TP16 (HI) and TP1 (LO).

8. Adjust R17 for a DMM reading between 6.1999 and 6.2001V dc. Ignore any thermometer display.

4-32. Reference Adjustment

4-33. Perform the reference adjustment using the following procedure:

1. Select a thermometer input, from the voltage divider, of 99 mV dc.

2. Adjust +FS (R29) through the front panel access port for a display between 9899.9 and 9900.1.

3. Reverse the polarity of the input by reversing the polarity of the calibrator output.

4. Adjust -FS (R30) through the front panel access port for a display between 9899.9 and 9900.1.

5. Select a thermometer input, from the voltage divider, of 45 mV dc and verify the thermometer reads between 4499.9 and 4500.1.

4-34. Reference-Junction Adjustment

4-35. Perform the reference-junction adjustment using the following procedure:

1. Disconnect the voltage divider from the calibrator and the thermometer.

2. Select a calibrator output of +0.5785V dc.

CAUTION

Verify that the calibrator output is correct before applying it to the instrument.

3. Connect the calibrator between TP1 (HI) and TP17 (LO). Select switch position 1 (K) on the Thermocouple Input PCB Assembly, and short the thermocouple + and - input terminals with a short piece of copper bus wire.

4. Adjust R5 for a thermometer display of 77.0° F.

5. Disconnect the calibrator from the thermometer and remove the short on the thermocouple input terminals.

4-36. Thermocouple Input Calibration

4-37. Perform the thermocouple input calibration using the following procedure:

1. Connect a thermocouple to the thermometer input terminals (K-type preferred) select the applicable switch position and insert the probe into a lag bath.

2. Allow the system to stabilize, then adjust R1 on the Thermocouple Input Module through the rear access port for a temperature display equal to reading of the lag bath thermometer.

3. Calibration of the 2190A is complete. Disconnect all test equipment from the instrument.

4-38. SELECTED COMPONENT REPLACEMENT OR ADJUSTMENT

4-39. If the reference-junction transistor (Q1 on the Thermocouple Input PCB Assembly) is replaced or the negative supplies repaired, the reference-junction bias resistor R3 must also be replaced. R3 is a selected resistor and must be individually matched to Q1. Prior to the matching procedure, calibrate the instrument using the standard procedure through the reference-junction adjustment and then replace the thermocouple input calibration portion of the procedure with the following:

1. Connect a thermocouple probe to the input terminals and select the applicable switch setting on the Thermocouple Input PCB Assembly (K-type thermocouple preferred) and insert the probe into a lag bath.

2. Center the reference-junction potentiometer R1.

3. Connect a decade box (see Table 4-2) in place of the reference-junction bias resistor.

4. Adjust the decade-resistance box for the value from Table 4-4 that causes the temperature to read closest to the lag bath temperature as monitored on the mercury thermometer.

5. Remove power, disconnect the decade box, and connect the resistor selected from the table.

6. Reapply power, allow the system to stabilize at its rated accuracy (at least 5 minutes), then adjust R1 through the rear panel access port for a temperature display equal to the reading of the lag bath mercury thermometer.

7. Calibration and component selection is complete. Disconnect all test equipment from the instrument.

Table 4-4. Bias Resistor Values

VALUE	JOHN FLUKE PART NUMBER	VALUE	JOHN FLUKE PART NUMBER
49.9k	268821	110k	234708
52.3k	237248	124k	288407
54.9k	271353	140k	289439
57.6k	289116	162k	375998
60.4k	291419	191k	375923
63.4k	235382	237k	288373
68.1k	236828	309k	235283
73.2k	23722	332k	289504
78.7k	289058	464k	271908
84.5k	229492	562k	235358
90.9k	223537	1.05M	260737
100k	248807	∞	OPEN

4-40. Multipoint Potentiometer Adjustment

4-41. The multipoint potentiometer (R57) is set at the factory and should not require further adjustment unless one of the other resistors in the divider (R1 and R2) or the capacitor (C19) require replacement. Adjustment of the potentiometer requires that a Y2001 Multipoint Selector or a 2300A Scanner may be connected to the instrument. Adjust R57 subsequent to replacement of any of the four affected components (C19, R1, R2, or R57) using the following procedure:

1. Connect a Y2001 Multipoint Selector or a 2300A Scanner to the instrument.

2. Short the input to one channel on the Y2001 or 2300A Scanner and select that channel on the front panel. (If a 2300A is used, select delay of 0.0.)

3. Obtain an output of 578.5 mV dc from a test dc calibrator.

4. Apply the output of the dc calibrator to TP1 (HI) and TP18 (LO).

5. Adjust R57 for a thermometer display of 77.0° F.

4-42. TROUBLESHOOTING

4-43. Troubleshooting for the 2190A consists of the tabular flow chart in Table 4-5. When a step on the flow chart is completed check for a decision transfer. If no decision is required perform the next step of the table in sequence.

Table 4-5. 2190A Troubleshooting

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
1	Short the thermocouple input.		
2	Set the thermocouple selector switch to position 8 or 9 (Cal. pos.).		
3	Apply power to the thermometer.		
4	Does the display read 2190.X for ten seconds and then change to 0°C (0°F)? NOTE: X = A numeral depending on the version of software installed.	14	5
5	Does any portion of the display illuminate?	13	6
6	Measure between TP2 and TP4 for +5 ±10% VDC, between TP1 and TP3 for +15 ±5% VDC, and between TP1 and TP2 for -15 ±5% VDC.		
7	Are all voltages correct?	12	8
8	Measure between Pin 8 of T2 and the negative end of C21 for a DC voltage greater than 10.3V and for a peak to peak wave form between Pins 8 and 9 of T2 approximately twice the value of the DC voltage measured at Pin 8.		
9	Are both signals present and correct?	11	10
10	Check the inverter circuit that drives the transformer (T2). Repair as required then resume at Step 3.		
11	Check the transformer secondaries and if any are bad, check the individual regulators and their associated components. NOTE: Analog circuitry may load down the ±15V supplies. Repair as required then resume at Step 3.		
12	Check the +5V path the the Display PCB and the Display PCB Connector. Repair as required then resume at Step 3.		
13	Check the strobes (U4-3, 4, 5, 6, 19) and display seven segment control lines (U4-8, 9, 10, 11, 12, 13, 14). Repair as required then resume at Step 3.		
14	Remove the input short.		

Table 4-5. 2190A Troubleshooting (cont)

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
15	Does the display read "0.C."?	17	16
16	Check U14-1, U14-2, U14-13 outputs and their associated components. Repair as required then resume at Step 14.		
17	Set the thermocouple selector switch to the setting of the type thermocouple to be connected in the next step.		
18	Connect a thermocouple to the thermometer and measure some known temperature.		
19	Is the displayed temperature correct?	41	20
20	Does the display read a flashing "O.C."?	21	22
21	Check the thermocouple components and the open thermocouple circuit (U14-1, U14-2, U14-13 and their associated components). Repair as required then resume at Step 17.		
22	Can the Calibration Adjustment Procedure be performed?	41	23
23	Are the control signals at U4 pins 26 through 32 toggling between high and low logic levels? NOTE: The INT 3 signal at pin 28 of U4 will remain low (0V) unless the multipoint selector accessory (Y2001) is connected. (Use TP2 as common.)	25	24
24	Replace the microcomputer U4 then resume at Step 17.		
25	Are the outputs of U3 and TP14 toggling between high and low logic levels? NOTE: The output at pin 9 of U3 will remain low (0V) unless the multipoint selector accessory (Y2001) is connected.	27	26
26	Check U3, Q4 and their associated components. Repair as required then resume at Step 17.		
27	Is the waveform at TP7 as shown in Figure 3-2 (Magnitude & Polarity varies with the input signal)?	34	28
28	Is there-6.2 Vdc at TP16. (Use TP1 as common.)	30	29
29	Check the Reference Circuit providing an input at U7-3 from the divider R18, R19, R17, R20, and VR1. Repair as required and resume at Step 17.		
30	Check from TP1 (analog ground) to U9-6 for 100 mV dc and for 200 mV dc at U9-9.		
31	Are both voltages present?	33	32
32	Check Q11, Q12, Q13 and associated components. Repair as required then resume at Step 17.		
33	Check the Thermocouple Input PCB plus U8-1, Q14, Q15, Q17, and their associated components. Repair as required then resume at Step 17.		
34	Is the waveform at U8-7 as shown in Figure 3-2 (Magnitude & Polarity varies with the input signal)?	38	35
35	Check the operation of Q7, Q8, Q9, Q10, U8 and their associated components. If any defective components are found, repair as required and resume at Step 13. If none are found proceed to the next step.		
36	Connect TP2 and TP5 with a jumper to lock the instrument in the Auto Zero period.		
37	Check U8, U2, U6 and their associated components. This circuit should now function as a closed loop amplifier. Repair as required. Remove the jumper between TP2 and TP5 and resume at Step 17.		

Table 4-5. 2190A Troubleshooting (cont)

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
38	Does TP10 toggle between the high and low logic levels?	40	39
39	Check U1 and its associated components then resume at Step 17.		
40	Replace the microcomputer U4, then resume at Step 17.		
41	Troubleshooting of the 2190A is complete. Remove all test equipment, reconnect any cables removed and close the instrument.		

Section 5
List of Replaceable Parts

TABLE OF CONTENTS

5-1. INTRODUCTION

5-2. This section contains an illustrated parts breakdown of the instrument. A similar parts listing for each of the Options will be found in Section 6. Components are listed alphanumerically by assembly. Both electrical and mechanical components are listed by reference designation. Each listed part is shown in an accompanying illustration.

5-3. Parts lists include the following information:

1. Reference Designation.

2. Description of each part.

3. FLUKE Stock Number.

4. Federal Supply Code for Manufacturers. (See Section 7 for Code-to-Name list.)

5. Manufacturer's Part Number.

6. Total Quantity per assembly or component.

7. Recommended Quantity: This entry indicates the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of each assembly in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc., that are not always part of the instrument, or are deviations from the basic instrument model, the REC QTY column lists the recommended quantity of the item in that particular assembly.

5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the FLUKE STOCK NUMBER. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions if necessary.

5-6. To ensure prompt and efficient handling of your order, include the following information.

1. Quantity.

2. FLUKE Stock Number.

3. Description.

4. Reference Designation.

5. Printed Circuit Board Part Number.

6. Instrument Model and Serial Number.

CAUTION

*** Indicates MOS devices which may be damaged by static discharge.**

Table 5-1. 2190A Final Assembly
(See Figure 5-1.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N O T -E-
A 1	*	MAIN PCB ASSEMBLY	469395	89536	469395	1		
A 2	*	DISPLAY PCB ASSEMBLY	464479	89536	464479	1		
A 3	*	THERMOCOUPLE INPUT PCB ASSY	469403	89536	469403	1		
F 1		FUSE,1/4 X 1-1/4,SLOW,0.75A,250V	109256	71400	MDX3-4	1	5	
F 2		FUSE,1/4 X 1-1/4,SLOW,0.125A,250V	166488	71400	MDL1-8A			
F 3		FUSE,1/4 X 1-1/4,SLOW,0.063A,250V	163030	71400	MDL1-16A		5	
H 1		SCREW,MACH,FH,P,STL,6-32X0.625	114876	89536	114876	4	1	
H 2		WASHER,LOCK,INTRNL,STEEL,0.512 ID	641381	89536	641381	2		
H 3		SCREW,THD FORM,PHP,STL,6-20X3/8	288266	89536	288266	1		
H 4		SCREW,MACH,PH,P,SS,4-40X.250	256156	89536	256156	3		
H 5		SCREW,MACH,PH,P,SS,4-40X.375	256164	89536	256164	2		
H 6		SCREW,MACH,FHP,BR,4-40X3/8	493932	89536	493932	1		
MP 1		NAMEPLATE, SERIAL -REAR PANEL-	472795	89536	472795	1		
MP 2		FACTORY MUTUAL DECAL	524611	89536	524611	1	1	
MP 3		DECAL CSA	525527	89536	525527	1		
MP 5		BASE-STANDARD	454702	89536	454702	1		
MP 6		GUARD,BASE	464404	89536	464404	1		
MP 7		"C" SIZE COVER ASSY	516708	89536	516708	1		
MP 8		REAR PANEL	464149	89536	464149	1		
MP 9		OUTPUT OPTION COVER	464412	89536	464412	1		
MP 10		LIMITS COVER	464156	89536	464156	1		
MP 11		DECAL,TYPE SELECT SWITCH SETTING	523597	89536	523597	1		
MP 12		BAIL	467555	89536	467555	1		
MP 13		FOOT,NONSKID	467571	89536	467571	4		
MP 14		DECAL,REAR PANEL	454645	89536	454645	1		
MP 15		CALIBRATION COVER	471490	89536	471490	1		
MP 16		DECAL,BOTTOM	473629	89536	473629	1		
MP 17		DECAL,BASE SIDES	473652	89536	473652	2		
MP 18		DECAL FRONT PANEL	453233	89536	453233	1		
MP 19		HLDR PART,FUSE,BODY 1/4X1-1/4,5X20MM	375188	61935	031.1653	2		
MP 21		CARD GUIDE	464164	89536	464164	2		
MP 22		HLDR PART,FUSE,CAP,1/4X1-1/4	460238	61935	031.1666	2		
MP 23		CABLE TIE,4"L,0.100"W,0.75 DIA	172080	89536	172080	1		
MP 24		LATCH	467548	89536	467548	2		
MP 25	*	FRONT PANEL WITH HARDWARE	655522	89536	655522	1		
MP 27		TERM,RING 3/32 & 1/8,SOLDR	151431	79963	329	1		
TM 1		2190A INSTRUCTION MANUAL	489229	89536	489229	1	5	
U 4	*	IC,NMOS,8 BIT MICROCOMPUTR,2190A-9406	525634	89536	525634			1
U 4	*	IC,NMOS,8 BIT MICROCOMPUTR,2190A-9407	525642	89536	525642		1	2
U 4	*	IC,NMOS,8 BIT MICROCOMPUTR,2190A-9409	534990	89536	534990			3
W 1		CORD,LINE,5-15/IEC,3-18AWG,SVT	343723	89536	343723	1		
W 2		CABLE ASSY	475228	89536	475228	1		

An * in 'S' column indicates a static-sensitive part.

NOTES:

1 = For J,K,E,S,R type thermocouples.
2 = For JDIN,TDIN,K,R,B type thermocouples.
3 = For J,K,T,C,R type thermocouples.

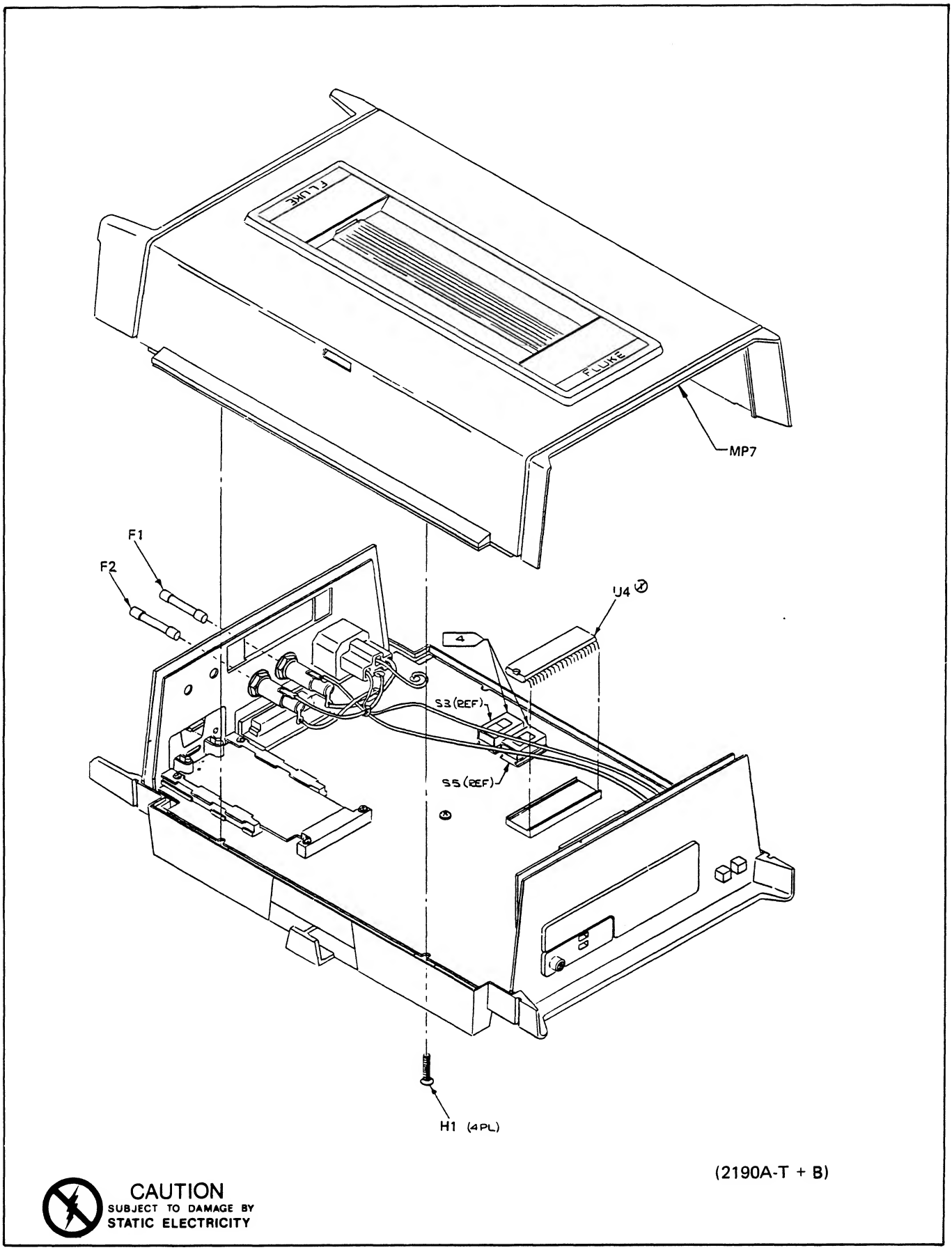


Figure 5-1. Final Assembly

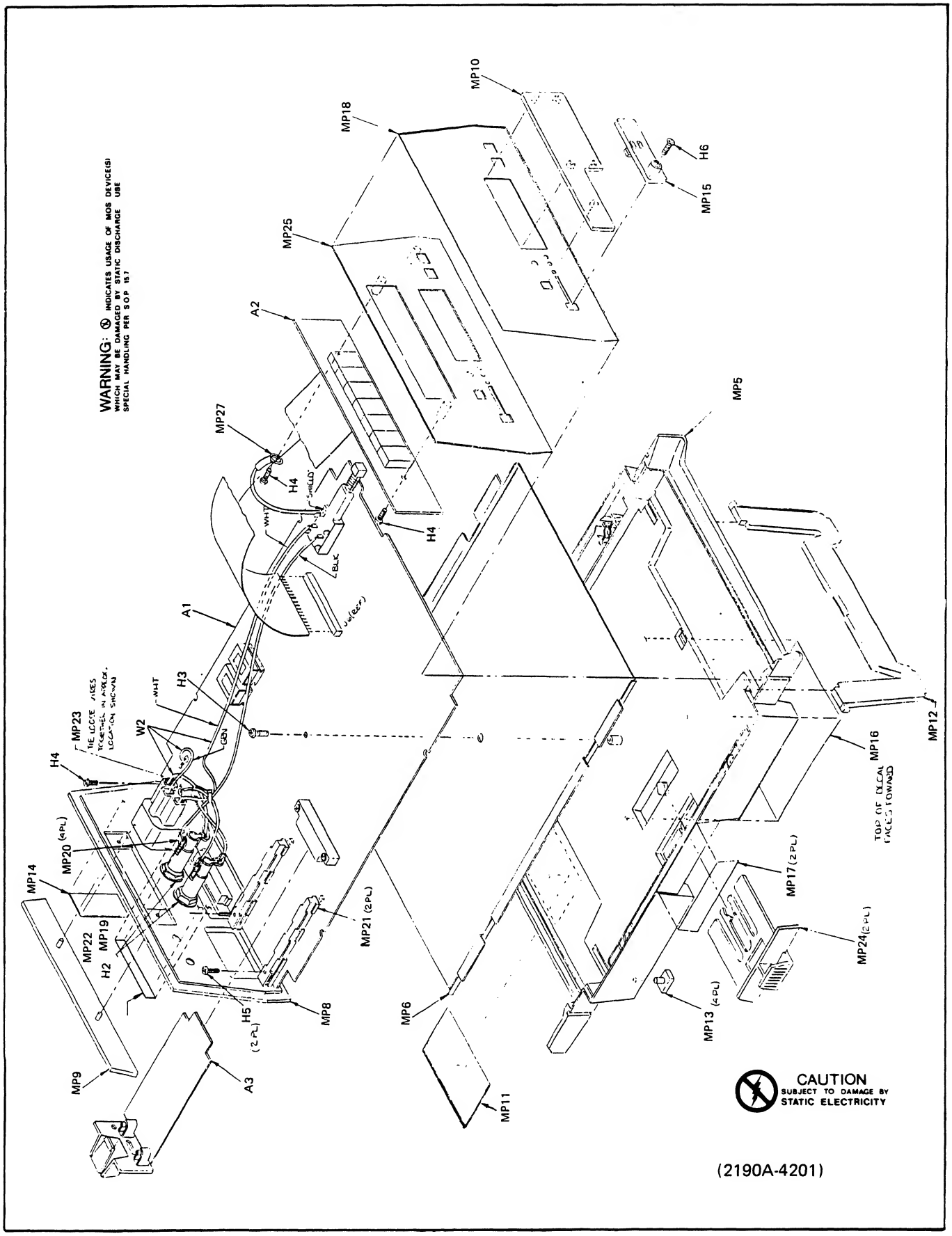


Figure 5-1. Final Assembly (cont)

Table 5-2. A1 Main PCB Assembly
(See Figure 5-2.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N O T -E-
C 1		CAP,MICA,47PF,+-5%,500V	148536	72136	CM15E470J	1	1	
C 2		CAP,POLYPR,0.47UF,+-5%,50V,HERMETIC	364042	84411	JF788	1		
C 3, 4, 6-		CAP,TA,10UF,+-20%,20V	330662	56289	196D106X0020KA1	13		
C 9, 11, 14,			330662					
C 15, 24, 28,			330662					
C 29, 33			330662					
C 5		CAP,CER,0.0012UF,+-10%,500V,Z5R	106732	71590	CF122	1		
C 10		CAP,POLYCA,2.2UF,+-10%,100V	306522	73445	C280MCH/A2M2	1		
C 12, 13, 16,		CAP,MICA,430PF,+-5%,500V	177980	14655	CD15FD431J0	4		
C 17			177980					
C 18		CAP,TA,10UF,+-20%,35V	417683	56289	196D106X0035KA1	1		
C 19, 20		CAP,CER,0.01UF,+80-20%,25V,Y5U	335786	72982	5835-000Y5-U103Z	2		
C 21		CAP,AL,4700UF,+75-20%,25V	614115	89536	614115	1		
C 23, 31, 32,		CAP,TA,1UF,+-10%,35V	161919	56289	196D010X0035G	5		
C 34, 36			161919					
C 25		CAP,TA,39UF,+-20%,20V	358234	56289	196D396X0020PE4	1		
C 26, 27		CAP,TA,22UF,+-20%,35V	394775	56289	196D226X0035TE4	2		
C 30		CAP,POLYES,0.047UF,+-10%,250V	162008	73445	C280MAE/A47K	1		
C 35		CAP,CER,0.22UF,+-20%,50V,Z5U	309849	71590	CW3C0C224K	1		
CR 3	*	DIODE,SI,RECT,BRIDGE,BV=100V,IO=1.0A	392910	09423	FB200	1	3	
CR 4, 5, 9-	*	DIODE,SI,BV=75V,IO=150MA,500MW	203323	07910	1N4448	12		
CR 12, 15- 18,	*		203323					
CR 20, 21	*		203323					
CR 6	*	DIODE,SI,100 PIV,1.5 AMP	116111	05277	1N4817	1	1	
CR 7, 8	*	DIODE,SI,50 PIV,1.0 AMP	379412	04713	1N4933	2	1	
H 1		NUT,PRESS,BROACH,STL,4-40	380196	24347	KF2-440	9	1	
H 2		INSERT,STUD,BROACHING,PHOSPHOR BRONZE	493833	89536	493833	4		
H 3		CONN,D-SUB,PWB,RT ANGL,25 SCKT,. 590	461996	00779	206584-1	1		
H 4		WASHER,LOCK,SPLIT,STEEL,#4	110395	89536	110395	2		
H 5		SCREW,MACH,PH,P,STL.4-40X1. 500	156380	73734	19032	2		
H 6		SCREW,MACH,SEMS,PH,P,STL,4-40X. 500	353060	89536	353060	2		
H 7		SCREW,MACH,PH,P,4-40X0.375	837690	89536	837690	2		
H 8		WASHER,FLAT,BRASS.#40.025	110775	89536	110775	2		
J 1		SOCKET,1 ROW,PWB,0. 100CTR,4 POS	461756	00779	583773-1	1		
J 2		CONN,PWB EDGE,REC,90,0.156 CTR,12 POS	474007	05574	2VH6/1AKC15	1		
J 3		SOCKET,1 ROW,PWB,0. 100CTR,6 POS	448209	00779	1-583773-3	1		
J 4		SOCKET,1 ROW,PWB,0.100CTR,7 POS	484030	00779	1-583773-4	1		
J 6		SOCKET,1 ROW,PWB,0. 100CTR,18N POS	435024	00779	583773-8	1		
K 1		RELAY,REED,1 FORM A,4. 5VDC	357582	71707	UF40070	1		
MP 1		CABLE TIE,5-1/2"L,0. 100"W,1. 25 DIA	530360	89536	530360	1		
MP 2		HEAT DIS,CLIP,TO-220	428805	13103	6046P8	1		
MP 3		BUTTON,MODIFIED, GREEN	644435	89536	644435	1		
MP 4		BUTTON,MODIFIED,LT. GRAY	540724	89536	540724	1		
MP 5	*	SLEEV,POLYOL,SHRINK,.250-.125ID,BLACK	113837	89536	113837			
MS 1, 3		RES,SET,MF,TC,MATCHED	479030	89536	479030	2		
Q 2, 3, 9,	*	TRANSISTOR,SI,N-JFET,TO-92	343830	12040	NSSF50024	8	1	
Q 16- 18, 24,	*		343830					
Q 25	*		343830					
Q 4, 5, 21,	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	4	1	
Q 23	*		218396					
Q 6, 8, 11-	*	TRANSISTOR,SI,N-JFET,TO-92	376475	15818	U2810J	6	2	
Q 13, 15	*		376475					
Q 7	*	TRANSISTOR,SI,N-JFET,DUAL,TO-71	419283	89536	419283	1	1	
Q 10	*	TRANSISTOR,SI,N-JFET,REMOTE CUTOFF	429977	89536	429977	1	2	
Q 13, 14	*	DIODE,SI,N-JFET,CURRENT REG,IF=1.0 MA	348482	89536	348482	2	1	
Q 14	*	DUAL FET,SELECTED OFFSET	476911	78425	476911	1	1	
Q 19, 20	*	TRANSISTOR,SI,BV= 80V, 10W,TO-202	495697	04713	MPS-U06	2	1	
Q 22	*	TRANSISTOR,SI,BV= 40V, 2W,TO-220	473207	01295	TIP30	1	1	
R 5, 57		RES,VAR,CERM,200,+-10%,0.5W	275743	89536	275743	2		
R 6		RES,CF,1K,+-5%,0.25W	343426	80031	CR251-4-5P1K	1		
R 1	*		377283					
R 7, 44, 46,		RES,CF,10K,+-5%,0.25W	348839	80031	CR251-4-5P10K	5		
R 47, 60			348839					
R 8, 34		RES,CF,3.3K,+-5%,0.25W	348813	80031	CR251-4-5P3K3	2		
R 9		RES,CF,43K,+-5%,0.25W	442418	80031	CR251-4-5P43K	1		
R 10		RES,CF,27K,+-5%,0.25W	441501	80031	CR251-4-5P27K	1		
R 11, 12, 26,		RES,MF,10.02K,+-0.1%,0.125W,50PPM	352245	89536	352245	4		
R 27			352245					
R 13		RES,MF,1K,+-1%,0.125W,100PPM	168229	91637	CMF551001F	1		

An * in 'S' column indicates a static-sensitive part.

Table 5-2. A1 Main PCB Assembly (cont.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N O T -E-
R 15		RES,MF,49.9,+-1%,0.125W,100PPM	305896	91637	CMF5549R9F	1		
R 16		RES,MF,169K,+-1%,0.125W,100PPM	289454	91637	CMF551693F	1		
R 17		RES,VAR,CERM,500,+-10%,0.5W	325613	89536	325613	1		
R 20		RES,MF,61.9K,+-1%,0.125W,100PPM	237230	91637	CMF556192F	1		
R 21		RES,MF,215K,+-1%,0.125W,100PPM	289470	94637	CMF552153F	1		
R 22		RES,CF,12K,+-5%,0.25W	348847	80031	CR251-4-5P12K	1		
R 23		RES,MF,22.1K,+-1%,0.125W,100PPM	235234	91637	CMF552212F	1		
R 24		RES,MF,221,+-1%,0.125W,100PPM	340794	91637	CMF552210F	1		
R 25		RES,MF,100,+-0.1%,0.125W,25PPM	357400	91637	CMF551000B	1		
R 28		RES,MF,200,+-0.1%,0.125W,25PPM	474262	91637	CMF552000B	1		
R 29, 30		RES,VAR,CERM,1K,+-20%,0.5W	267856	11236	190PC102B	2		
R 31		RES,VAR,CERM,20K,+-20%,0.5W	267898	11236	190PC203B	1		
R 32		RES,MF,10,+-1%,0.125W,100PPM	268789	91637	CMF5510R0F	1		
R 33		RES,CC,5.1M,+-5%,0.25W	296467	01121	CB5155	1		
R 35, 70		RES,CF,330,+-5%,0.25W	368720	80031	CR251-4-5P330E	2		
R 37		RES,CF,100,+-5%,0.25W	348771	80031	CR251-4-5P100E	1		
R 38		RES,MF,9.09K,+-1%,0.125W,100PPM	221663	91637	CMF559091F	1		
R 39		RES,MF,1.02K,+-1%,0.125W,100PPM	223545	91637	CMF551021F	1		
R 40		RES,MF,4.32K,+-1%,0.125W,100PPM	294819	91637	CMF554321F	1		
R 41		RES,MF,10K,+-1%,0.125W,100PPM	168260	91637	CMF551002F	1		
R 43		RES,CF,16K,+-5%,0.25W	442376	80031	CR251-4-5P16K	1		
R 45, 53, 54		RES,CF,100K,+-5%,0.25W	348920	80031	CR251-4-5P100K	3		
R 48		RES,MF,150K,+-1%,0.125W,100PPM	241083	91637	CMF551503F	1		
R 49		RES,MF,681K,+-1%,0.125W,100PPM	381517	91637	CMF556813F	1		
R 50		RES,CF,47K,+-5%,0.25W	348896	80031	CR251-4-5P47K	1		
R 51		RES,MF,38.3K,+-1%,0.125W,100PPM	241372	91637	CMF553832F	1		
R 52		RES,MF,133K,+-1%,0.125W,100PPM	289074	91637	CMF551333F	1		
R 55		RES,CF,5.1K,+-5%,0.25W	368712	80031	CR251-4-5P5K1	1		
R 56		RES,MF,10.2K,+-1%,0.125W,100PPM	293605	91637	CMF551022F	1		
R 58		RES,CF,51K,+-5%,0.25W	376434	80031	CR251-4-5P51K	1		
R 59, 66		RES,CF,39K,+-5%,0.25W	442400	80031	CR251-4-5P39K	2		
R 61, 63		RES,CF,470K,+-5%,0.25W	342634	80031	CR251-4-5P470K	2		
R 62, 64		RES,CF,4.7K,+-5%,0.25W	348821	01121	CB4725	2		
R 65		RES,MF,309K,+-1%,0.125W,100PPM	235283	91637	CMF553093F	1		
R 67		RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF551003F	1		
R 68		RES,MF,64.9K,+-1%,0.125W,100PPM	288530	91637	CMF556493F	1		
R 69		RES,MF,226K,+-1%,0.125W,100PPM	320879	91637	CMF552263F	1		
S 1, 2		SWITCH PUSHBUTTON ASSY	483891	89536	483891	1	1	
S 3, 5		SWITCH,SLIDE,DPDT,POWER	234278	89536	234278	2		
S 4		SWITCH,SLIDE,DPDT	423129	89536	423129	1		
T 1		POWER TRANSFORMER	464370	89536	464370	1		
T 2		TRANSF,INV,MULTIPLE OUTPUT,TOROID	461954	89536	461954	1		
TB 1, 2		TERM STRIP,PWB,RT ANG,0.200CTR,2 POS	479006	89536	479006	2		
TP 2- 6, 9,		TERM,UNINSUL,FEEDTHRU,HOLE,TURRET	179283	88245	2010B-5	7		
TP 16			179283					
U 1	*	IC,COMPARATOR,8 PIN DIP	352195	01295	SN72311P	1		
U 2	*	IC,OP AMP,JFET INPUT,TO-5 CASE	429837	12040	LF356F	1	1	
U 3	*	IC,CMOS,HEX OPEN DRAIN BUFFER	473389	12040	MM74C906N	1		
U 5	*	RES,NET,SIP,8 PIN,7 RES,47K,+-2%	413286	89536	413286	1		
U 6	*	IC,OP AMP,JFET INPUT,8 PIN DIP	472779	12040	LF386N	1	1	
U 7	*	IC,OP AMP,GENERAL PURPOSE,8 PIN DIP	413740	12040	LM307N	1	1	
U 8	*	IC,OP AMP,SOURCE CNTRLD,DUAL,LO-NOISE	478032	04713	MC4558NCP1	1	1	
U 9	*	RES NET ASSY TESTED (2180/2190DIV)	510628	89536	510628	1		
U 9	*	REF DIV RES NET ASSY TESTED 2180/2190	577536	89536	577536	1		
U 10	*	IC,OP AMP,SELECTED GBW 600KHZ	418566	12040	LM358N	1	1	
U 11	*	IC,VOLT REG,FIXED,-15 VOLTS,1.5 AMPS	413179	04713	MC7915CP	1	1	
U 12	*	IC,VOLT REG,FIXED,+15 VOLTS,1.5 AMPS	413187	04713	MC7815CT	1	1	
U 14	*	IC,COMPARATOR,QUAD,14 PIN DIP	387233	12040	LM339N	1	1	
VR 2, 3	*	ZENER,UNCOMP,36.0V,5%,3.4MA,0.4W	186163	04713	1N974B	2	1	
VR 4	*	ZENER,UNCOMP,22.0V,5%,5.6MA,0.4W	181073	04713	1N969B	1		
VR 19	*	ZENER,COMP, 6.4V, 2%, 2 PPM TC, 0.5MA	393579	04713	1N4567	1	1	
XU 1	*	SOCKET,IC,40 PIN	429282	09922	DILB40P-108	1	1	
Y 1	*	CRYSTAL,4MHZ,+-0.02%,HC-18/U	474072	89536	474072	1	1	
Z 13		RES,NET,DIP,16 PIN,8 RES,680,+-5%	402644	89536	402644	1	1	

An * in 'S' column indicates a static-sensitive part.

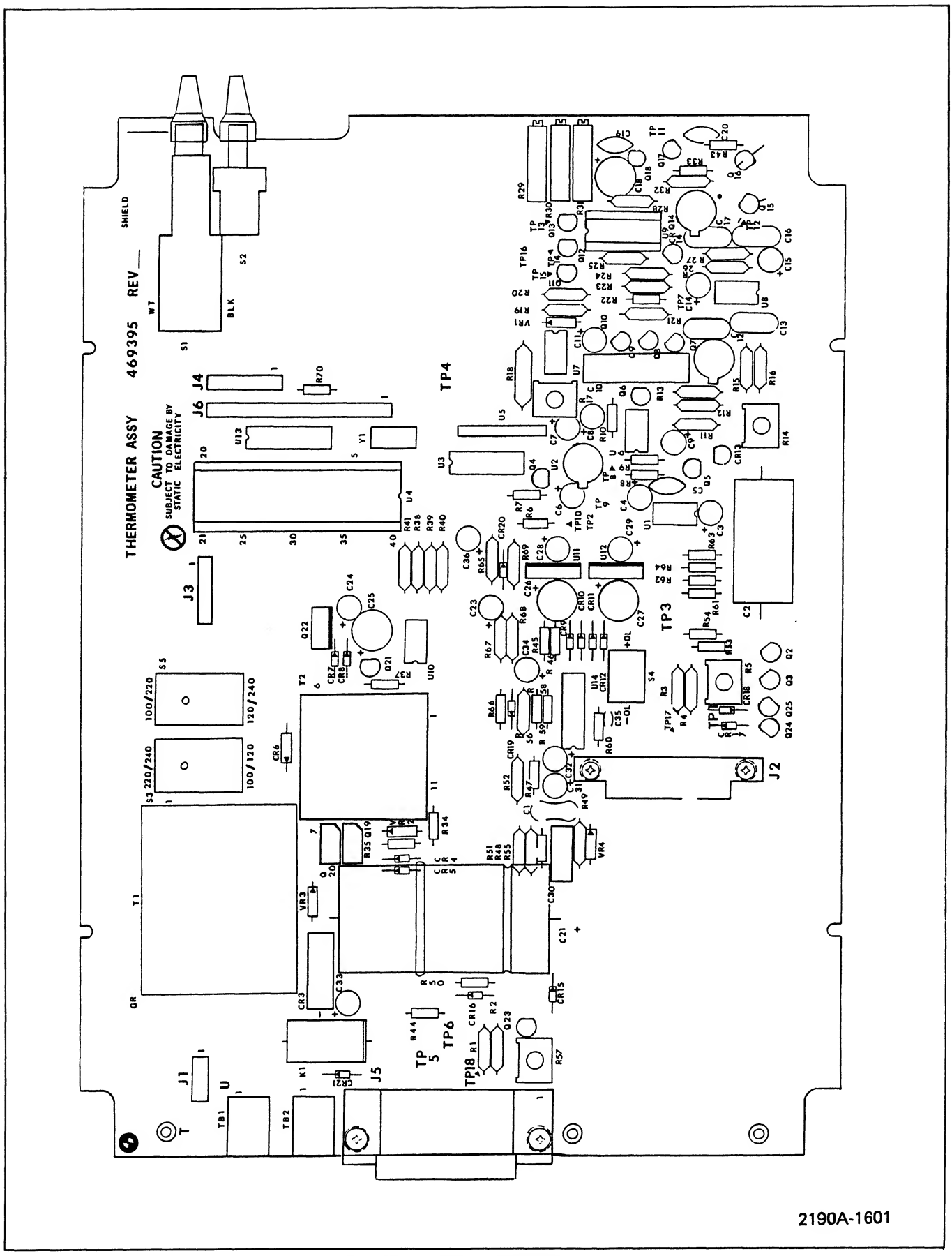


Figure 5-2. A1 Main PCB Assembly

Table 5-3. A2 Display PCB Assembly
(See Figure 5-3.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N O T -E-
DS 1- 5, 7		LED,RED,7 SEGMENT,NUMERIC	418012	28480	5082-7651	6		
MP 1		PART NO. DECAL,DISPLAY	477042	89536	477042	1		
Q 1- 13	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	64713	2N3906	13		
R 1, 2		RES,CF,100,+-5%,0.25W	348771	80031	CR251-4-5P100E	2		
U 1	*	IC,ARRAY,5 TRANS,NPN,5 ISOLATED TRANS	418574	02735	CA3083E	1		
U 2		RES,NET,DIP,14 PIN,7 RES,1K,+-5%	407445	01121	314	1	1	
U 3		RES,NET,DIP,16 PIN,8 RES,82,+-5%	478859	89536	478859	1		
P 6		CABLE,FLAT,18CONDUCT,.100SP,JUMPER	474411	00779	1-86947-7	1	2	

An * in 'S' column indicates a static-sensitive part.

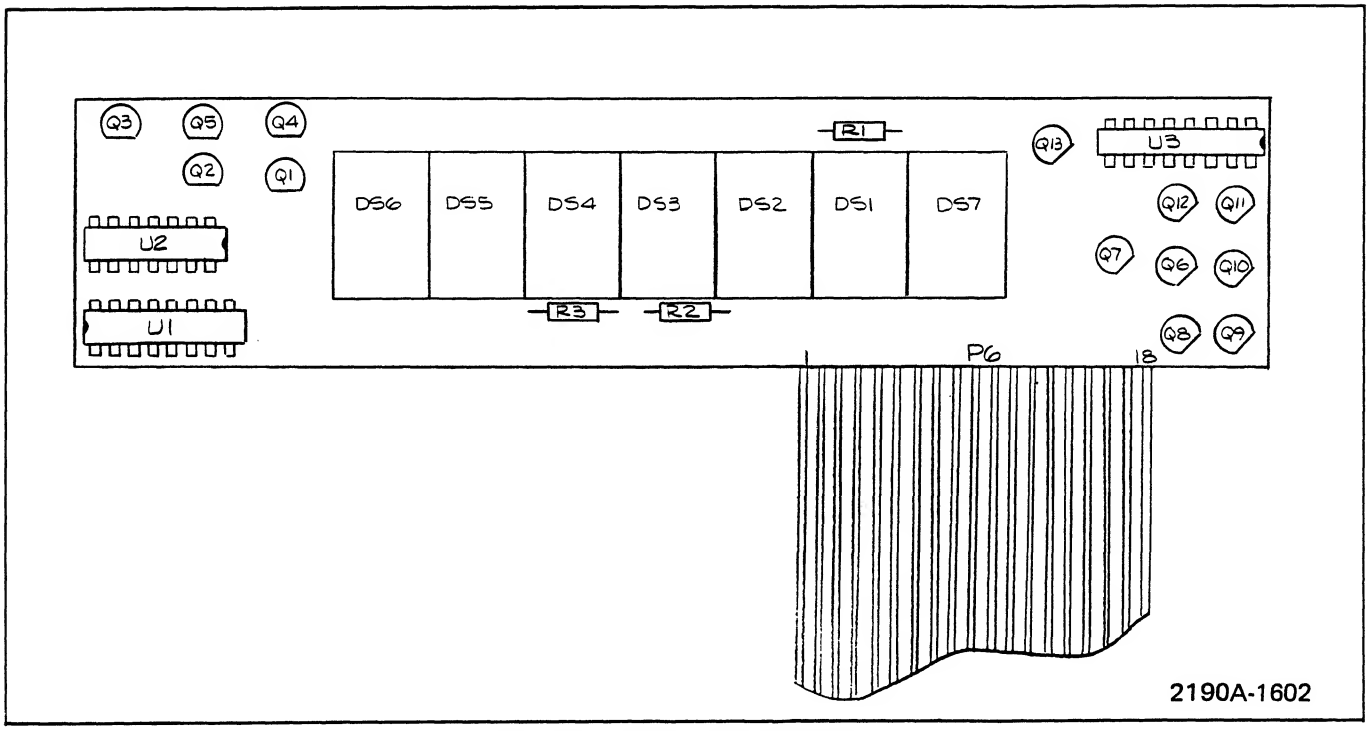


Figure 5-3. A2 Display PCB Assembly

Table 5-4. A3 Thermocouple Input PCB Assembly
(See Figure 5-4.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N O T -E-
C 1	*	CAP,POLYCA,2.2UF.+-10%.100V	306522	73445	C280MCH/A2M2	1		
C 2		CAP,MICA,150PF,+-5%,500V	148478	72136	DM15F151J	1		
C 3, 4		CAP,TA,1UF,+-10%,35V	161919	56289	196D010X0035G	2		
H 1		WASHER,FLAT,FIBER,#4,0.031 THK	110890	89536	110890	2		
H 2		SCREW,MACH,PH,P,SS,6-32X.250	844951	89536	844951	2		
H 3		WASHER,LOCK,SPLIT,STEEL,#4	110395	89536	110395	2		
H 4		SCREW,MACH,RHP,BR,4-40X3/8	615716	89536	615716	2		
H 5		SCREW,MACH,PH,P,SS,4-40X.437	403782	89536	403782	2		
H 6		NUT,PRESS,BROACH,STL,4-40	380196	24347	KF2-440	2		
MP 1		INPUT DRAWER	464123	89536	464123	1		
MP 2		POSITIVE THERMOCOUPLE INPUT	472381	89536	472381	1		
MP 3		NEGATIVE THERMOCOUPLE INPUT	472399	89536	472399	1		
MP 4		INSULATOR,THERMOCOUPLE INPUT	473561	89536	473561	1		
MP 5		PACER,SWAGED,RND,BRASS,4-40X0.070	343996	89536	343996	4		
Q 1	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	329698	89536	329698	1	1	
R 1	*	RES,VAR,CERM,100K,+-20%,0.5W	268581	71450	190PC104B	1		
R 2		RES,MF,255K,+-,0.125W,100PPM	221630	91637	CMF55	1		
R 3		RES,MF,90.9K,+-1%,0.125W,100PPM	223537	89536	223537			1
R 3		RES,MF,84.5K,+-0.5%,0.125W,100PPM	229492	89536	229492			1
R 3		RES,MF,110K,+-1%,0.125W,100PPM	234708	91637	CMF551103F			1
R 3		RES,MF,309K,+-1%,0.125W,100PPM	235283	91637	CMF553093F			1
R 3		RES,MF,562K,+-1%,0.125W,100PPM	235358	89536	235358			1
R 3		RES,MF,63.4K,+-1%,0.125W,100PPM	235382	89536	235382			1
R 3		RES,MF,68.1K,+-1%,0.125W,100PPM	236828	91637	CMF556812F			1
R 3		RES,MF,73.2K,+-1%,0.125W,100PPM	237222	91637	CMF557322F			1
R 3		RES,MF,52.3K,+-1%,0.125W,100PPM	237248	91637	CMF555232F			1
R 3		RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF551003F			1
R 3		RES,MF,1.05M,+-1%,0.125W,100PPM	260737	89536	260737			1
R 3		RES,MF,49.9K,+-1%,0.125W,100PPM	268821	91637	CMF554992F			1
R 3		RES,MF,54.9K,+-1%,0.125W,100PPM	271353	91637	CMF555492F			1
R 3		RES,MF,464K,+-1%,0.125W,100PPM	271908	91637	CMF554643F			1
R 3		RES,MF,237K,+-1%,0.125W,100PPM	288373	91637	CMF552373F			1
R 3		RES,MF,124K,+-1%,0.125W,100PPM	288407	91637	CMF551243F			1
R 3		RES,MF,78.7K,+-1%,0.125W,100PPM	289058	11236	CMF557872F			1
R 3		RES,MF,57.6K,+-1%,0.125W,100PPM	289116	91637	CMF555762F			1
R 3		RES,MF,140K,+-1%,0.125W,100PPM	289439	91637	CMF551403F			1
R 3		RES,MF,332K,+-1%,0.125W,100PPM	289504	91637	CMF553323F			1
R 3		RES,MF,60.4K,+-1%,0.125W,100PPM	291419	91637	CMF556042F			1
R 3		RES,MF,191K,+-1%,0.125W,100PPM	375923	91637	CMF551913F			1
R 3		RES,MF,162K,+-1%,0.125W,100PPM	375998	91637	CMF55			1
R 4		RES,CC,47K,+-10%,2W	110015	01121	HB4731	1		
S 1		SWITCH,DIP,SPST,4 POS	408559	00779	435166-2	1		
TP 1		TERM,UNINSUL,FEEDTHRU,HOLE,TURRET	179283	88245	2010B-5	1		
U 1		IC,VOLT REG,FIXED,-12 VOLTS,0.1 AMPS	473819	07263	A79L12AWC	1		

An * in 'S' column indicates a static-sensitive part.

NOTE 1 = R3 is selected at test.

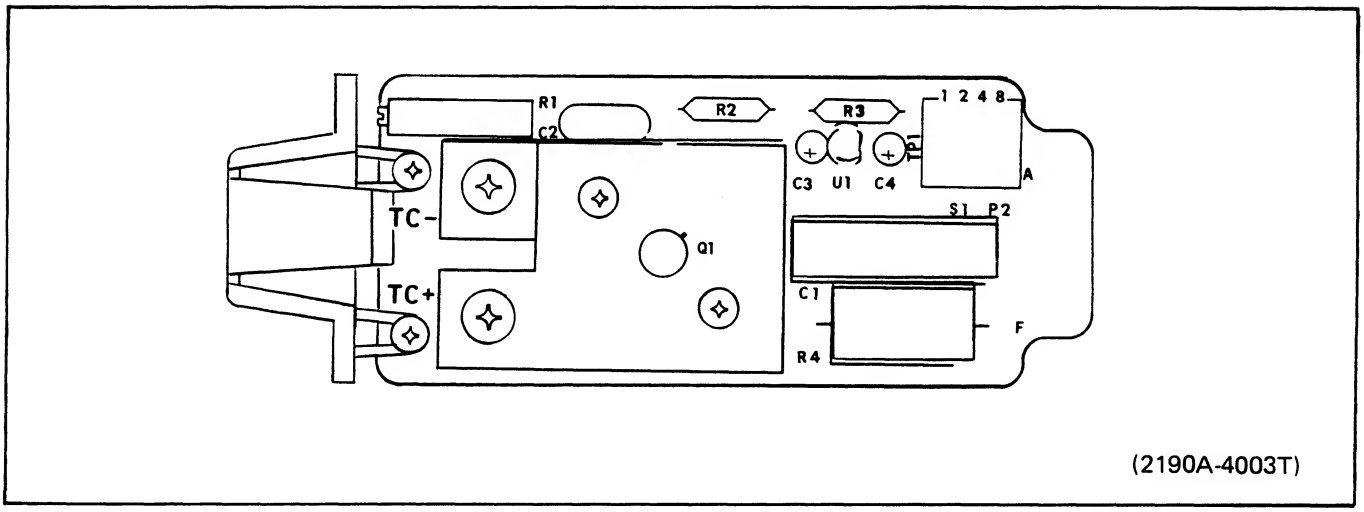


Figure 5-4. A3 Thermocouple Input PCB Assembly

Section 6
Option & Accessory Information

TABLE OF CONTENTS

6-1. INTRODUCTION

6-2. This section of the manual contains information on the accessories and options available for the 2190A Digital Thermometer.

6-3. ACCESSORY INFORMATION

6-4. The portion of this section dealing with accessories contains the details of all accessories available for the 2190A.

6-5. OPTION INFORMATION

6-6. Each of the options available for the 2190A are described separately in a subsection identified with the option name and number. The option description contains the information on the operating instructions and maintenance not covered in the main body of the text plus a complete list of replaceable parts for the option.

Accessories

600-1. GENERAL

600-2. Table 1-2 contains a list of the accessories available for use with the 2190A Digital Thermometer. The following paragraphs contain information on the types of accessories. Instructions for use accompany each accessory. In all cases, order using the accessory number listed.

600-3. MULTIPOINT SELECTOR, (Y2001)

600-4. The multipoint selector allows the operator to manually select and monitor one of up to ten channels. Two separate thermocouple types (maximum of five each if two types used) may be connected to the unit. Up to ten multipoint selectors may be connected in series.

600-5. CALIBRATOR, THERMOCOUPLE INDICATOR (Y2003)

600-6. This accessory, when used in conjunction with the 2190A, provides a variable output for calibration of less sensitive thermocouple devices than the 2190A. The 2190A display is controlled by the calibrator millivolt output (-10 to +90 mV dc) and the less sensitive thermometer may be adjusted to the 2190A displayed temperature. The Y2003 can perform remote calibrations using its self-contained battery pack as a source and can supply external power to the thermometer from this battery pack.

600-7. BATTERY PACK, 12V RECHARGEABLE (Y2009)

600-8. The rechargeable battery pack provides the 2190A and its accessories with portability. The output is +12V dc at a maximum of 750 mA for a total of 2.2 ampere-hours.

600-9. DIVIDER, THERMOMETER CALIBRATION (Y2022)

600-10. The device is a preset 100 to 1 divider to provide the precision millivolt outputs from a DC Calibrator required for calibration. The device wires into the Thermocouple Input PCB in place of the thermocouple probe during calibration. Refer to the Y2022 Instruction Manual for the schematic and additional information.

600-11. RACK PANELS

600-12. Available are rack mounting panels in three sizes and two types for the standard 19-inch electronics equipment racks. The "A" size for the multipoint selector is available in panels that will accomodate either one or two instruments. The "B" size panel for the calibrator and/or battery pack is also available for single or double instruments, as is the "C" size used for the 2190A Thermometer and the Alarms Output.

600-13. PANEL MOUNTS

600-14. The panel mounts provide the hardware to install the instrument in any panel in which a hole the size of the instrument front panel can be cut. It is available for the three instrument sizes required, "A", "B", and "C".

600-15. THERMOCOUPLE PROBES

600-16. Thermocouple probes are available from the John Fluke Mfg. Co., Inc. as determined by microcomputer type, see Table 1-3, Specifications.

600-17. POWER CORD, 3-WAY (Y2024)

600-18. This accessory is a specially constructed power cord with three female and one male connectors that allow the operator to connect up to "C" size or smaller PTI instruments with one line power cord.

600-19. CABLE OUTPUT UNIT, RS-232-C (Y2026B)

600-20. The Y2026B is an interface device which allows direct mating between any RS232C device and the -002 Output Option. The Y2026B consists of two 25-pin connectors, one 36-pin connector, and an accessory cable to connection between the 36-pin output and the -002 Output Option. It will be necessary for the user to provide the cable between the 25-pin outputs and the RS232C devices.

600-21. THERMOCOUPLE INPUT MODULE (Y2030)

600-22. The Y2030 is the thermocouple input module compatible with the 2190A Digital Thermometer only. Basically the Y2030 compensates for errors introduced by ambient temperature variations and allows the user to select the proper microcomputer program for the thermocouple type in use. For additional information and the schematic, please refer to the Model Y2030 Instruction Manual.

Option -002
Output

602-1. INTRODUCTION

602-2. The 21X0-002 Option is an analog and digital output unit. It provides either the 2180A or 2190A Model Digital Thermometers with a recording output for a permanent record when required. The option may be ordered with the unit for factory installation or is available as a kit for installation in the field.

602-3. The analog output is available on the rear panel at two flush banana jacks with the polarity indicated. The output is a scaled voltage source of 1 millivolt per degree of temperature, regardless of the temperature scale selected, with the polarity as read on the display. For example; a reading of 251°F would output +251 mV dc; 97.3°C would output +97.3 mV dc; and -31.9°F would output -31.9 mV dc.

602-4. The digital output is a clocked message that can be in two different formats to match the requirement of the customer's equipment. Output on one set of lines is a bit-parallel, byte-serial message format designed for printer interface. Also available are the standard EIA RS232C and current loop bit-serial outputs. Both formats provide the channel number, the current reading displayed, and any out of range or open thermocouple information.

602-5. SPECIFICATIONS

602-6. Specifications for the Output Option, 21X0-002, are as listed in Table 602-1.

Table 602-1. Specifications

Analog Output
- **Type:** Linearized and isolated.
- **Voltage:** 1.0 mV/ °C or °F from −425 mV to 4.5V, 5 mA max.
- **Temperature Coefficient:** 200 ppm/ °C from 25°C.
- **Noise:** ⩽100 uV at 100 Hz bandwidth.
- **Accuracy:** ±0.1% of reading ±1 mV.
- **Zero Drift:** 200 uV/°C from 25°C,
- **Warm-Up Time:** 5 minutes, to rated accuracy.

Digital Output
- **Types:** Three, E.I.A. Standard RS-232-C Type 2, TTY current loop, and parallel ASCII.
- **Connector:** 36-pin AMP "Champ".
- **Serial Baud Rates:** 110, 150, 300, 600, 1200, 2400, 4800, 9600, switch-selectable.
- **RS-232-C Signals:** Transmitted Data, Request to Send, Clear to Send, Data Set Ready, Signal Common.
- **Parallel ASCII Signals:** Data 8 lines, instrument address 3 lines, Address Valid, Data Valid, Acknowledge, ground, +5V.
- **Parallel ASCII Data Rate:** Three readings per second.
- **Parallel ASCII Interface:** Plug-to-plug compatible with similar Fluke equipment. CMOS compatible, drives one TTL load.
- **TTY Current Loop Signals:** Source and controlled sink, 20 mA.
- **Out-of-Limit Signal:** Exclamation point transmitted with Option 21X0-006 only; not with Y2002.
- **Battery Operation:** 4 to 5 hours typical at 25°C on fully charged Y2003 or Y2009.

602-7. INSTALLATION

602-8. Options for field installation can be installed using the following procedure:

1. Disconnect the thermometer from all input power sources.

2. Remove the screws on the bottom of the case that fasten the top and bottom of the PTI case together and remove the top half of the case.

3. Remove the center mounting screw that attaches the Main PCB to the case and lift the pcb clear of the case.

4. Attach the four spacers supplied with the option to the component side of the pcb in the holes forming a rough rectangular pattern (do not use the fifth hole on the corner, next to U1).

Table 602-2. Switch Selection

SWITCH POSITION	SWITCH BANK				S1 BAUD RATE	S2 FUNCTION	S3 ADDRESS
	1	2	3	4			
0	OFF	OFF	OFF	OFF	110	OPERATE	ADR 0
1	ON	OFF	OFF	OFF	150	CAL 1	ADR 1
2	OFF	ON	OFF	OFF	300	CAL 2	ADR 2
3	ON	ON	OFF	OFF	600	CAL 3	ADR 3
4	OFF	OFF	ON	OFF	1200	CAL 4	ADR 4
5	ON	OFF	ON	OFF	2400	CAL 1	ADR 5
6	OFF	ON	ON	OFF	4800	CAL 2	ADR 6
7	ON	ON	ON	OFF	9600	CAL 3	ADR 7
8	OFF	OFF	OFF	ON	110	PLOT 1	ADR 8
9	ON	OFF	OFF	ON	150	PLOT 2	ADR 9

5. Reinstall the Main PCB in the bottom half of the case.

6. On the Output Unit PCB use Table 602-2 and S1 to select the desired BAUD rate, select position 0 on the Function switch S2, and select the PTI Bus Address using S3. When using the RS-232-C interface, set the address switch S3 to address 1, 6, 7, 8, or 9. When using the 2XXXA-522 Personality Card and the 1120A IEEE-488 Translator, set the baud rate to 2400 and follow all procedures regarding the RS-232-C interface.

7. Connect the Output Unit cables to the connectors on the Main PCB.

8. Attach the Output Unit PCB to the spacers, component side down, and the connector to the rear panel access port.

9. Replace the PTI cover on the instrument and reconnect the input power sources, if required, at this time.

Table 602-3. Digital Output Connector Pin-Out

PIN NO.	FUNCTION	MNEMONIC	USE
1	Address Valid	ADRVAL	PTI Bus
2	Data Valid	DATVAL	PTI Bus
3-6	Printer Address	A0-A3	PTI Bus
7	Acknowledge	ACK	PTI Bus
8	Not Used		
9-16	Data	D0-D7	PTI Bus
17	Ground		PTI Bus
18	+5 Volts		PTI Bus
19-24	Not Used		
30	Transmitted Data		RS232 Interface
31	Request to send		RS232 Interface
32	Clear to send		RS232 Interface
33	Data set ready		RS232 Interface
34	Signal Common		RS232 Interface
35	S0+		Current Loop
36	S0–		Current Loop

602-9. OUTPUT CONNECTIONS

602-10. All connections between the Output Unit Option and external instruments are made using the rear panel connectors previously described. The analog output is from standard banana jacks. The digital output female connector has a mating male connector accompanying the option. This allows the customer to custom make a cable between the thermometer output option and the receiving device. Table 602-3, is the pin-out data for the digital output connector.

NOTE

Standard RS232C signals are output on 25-pins, the connector on the -002 Output Option is 36-pins, therefore, the user must either hardwire the connection between the -002 Output Option or order the Y2026B, Cable Adapter

602-11. OPERATION

NOTE

For RS232C or 20 mA current loop operation, the -002 address switches may be ignored.

The Data Set Ready (DSR, pin 33) or Clear To Send (CTS, pin 32) must be at +3V to +15V in order to output data on the RS232C bus. These lines can be tied to Request To Send (RTS), pin 31) which provides the required +15V.

602-12. Once the Output Unit Option is installed, the only operator functions deal with the connection of external equipment to the analog or digital output connectors.

602-13. The positive and negative analog terminals have available a dc millivolt output with the same polarity, and proportional to the temperature displayed. For example, if the thermometer displayed +105.7° F the analog output would be +105.7 mV dc and for -53.1°C the output would be -53.1 mV dc. The full resolution of the temperature display (tenths or hundredths of degrees) is reflected on the output.

602-14. The digital output can be connected to a printer or any device accepting parallel ASCII data, or to a device accepting RS232C or Current Loop signals. Connections for all three types of signals are available simultaneously on the 36-pin output connector previously described.

602-15. THEORY OF OPERATION

602-16. The Output Unit Option converts the temperature displayed by the output into a format usable by the customer's equipment. The output may be available as a scaled analog voltage or as formatted parallel and serial ASCII digital output. The following paragraphs describe operation of the Accessory Bus that handles communication between the instrument and the options, the analog output circuitry and the digital output circuitry. Refer to the schematic in Section 8 during the following discussion.

602-17. Accessory Bus Communication

602-18. The option communicates with the thermometer on the clocked bit-serial accessory bus. Transmitted on the bus are channel number, range, conversion type, scale, and digits of the temperature reading. When the WRTADR line is held low, DCLK clocks the address of the Output Unit (4), followed by the thermometer data to the microprocessor on the DATA line. Once into the microprocessor, the data is converted, formatted, and output to the analog and digital output circuitry.

602-19. Analog Circuitry

602-20. The temperature reading received by the microcomputer is used to generate an integrate control signal, the length of which is proportional to the magnitude of the temperature reading. This signal is used to turn on (close) the FET switches Q6 and U12-2, open the switches U11-2, U11-3 and U12-3, and set the output polarity with switches at U12-9 and U12-10. (U12-9 is closed when a negative reading is being processed and U12-10 when a positive signal is being processed.)

602-21. With Q6 on, the capacitor C1 is charged linearly to a voltage proportional to the length of the control signal at Q6. When Q6 has been on for the time required, it is opened, and switch U11-13 is closed, so the output of U13-8 can be sampled and held on C2. After 10 ms switch U11-3 opens and switch U11-11 closes to zero the integrate capacitor C1, until the next conversion cycle.

602-22. The voltage held on C2 is buffered by U13-7. U13-14 either passes the voltage directly to the output stage, or amplifies it as controlled by switches U12-9 and U12-10, which alternate states to set the polarity. The output stage at U13-1 has a constant gain of -1.

602-23. Digital Output Circuitry

602-24. The thermometer reading transmitted on the accessory bus every 333 ms is formatted by the microcomputer and, if requested, made available on the PTI Bus, RS232C, and current loop outputs. Refer to the schematics in Section 8 during the following description.

602-25. Eight data, four address, a data valid, an address valid, and an acknowledge line are used by the PTI Bus Interface. The external device requests data from the Output Unit by applying the preselected address to the address lines. The address is preselected by setting switch S3 to the desired number (0-9). When the proper address is decoded the tri-state output buffers (U8 and U9) are enabled, and the microcomputer and external device are notified that the Output Unit has a valid address. When the conversion process is complete, the microcomputer applies the first character of the formatted data to the output lines and pulls the DATVAL line low. The external device reads the data and pulls the ACK line low, causing the Output Unit to reply with a new character. The process is repeated until data transfer is complete. The message formats are shown in Figure 602-1, and a timing diagram is shown in Figure 602-2.

602-26. After transfer to the printer lines is complete, the microcomputer checks the DATA SET READY and CLEAR TO SEND lines from the RS232C Interface. If both lines are high, the same message as was output on the print lines is output on the RS232C and current loop lines in a bit-serial format. Since the thermometer cycle rate of 333 ms is shorter than the time required to output data at BAUD rate of 1200 and less, a message is not transmitted during every instrument cycle.

602-27. CALIBRATION

602-28. Analog circuitry in the option should be calibrated every 90 days or after any repair of the unit. The procedure following assumes that power is supplied to the unit and that a Digital Voltmeter capable of reading 10 μV on the 1 volt, or equivalent range, i.e., a Fluke Model 8800A, is available.

1. Remove power from the instrument.

2. Remove the top cover from the thermometer.

3. Remove the screws attaching the option pcb to the Main PCB.

4. Leaving the interconnect cables connected, turn the option pcb to the right, while facing the instrument, exposing the component side and making the switches and adjustment accessible.

5. Connect the DMM to the Analog Output Connector.

6. Apply power to the instrument and allow if to warm-up for a minimum of 5 minutes.

7. Set the FUNCTION switch (S2) to position 1 (CAL 1).

8. Adjust R26 for an output of 0 ± 0.1 mV dc.

9. Set the FUNCTION switch to position 2 (CAL 2).

10. Adjust R15 for an output of 0 ± 0.1 mV dc.

11. Set FUNCTION switch to position 3 (CAL 3).

12. Adjust R11 for an output of 10V ± 1 mV dc.

13. Set FUNCTION switch to position 4 (CAL 4).

14. Adjust R19 for an output of +10V ± 1 mV dc.

15. Remove power and the test DMM, then reinstall the option pcb on the Main PCB and the top cover on the instrument.

602-29. TROUBLESHOOTING

602-30. Troubleshooting for the 2180A Option -002, Output Unit, consists of the tabular flow chart in Table 602-4. When a step on the flow chart is completed, check for a decision transfer. If no decision is required, perform the next step of the table in sequence.

602-31. LIST OF REPLACEABLE PARTS

602-32. Table 602-5 is a list of replaceable parts for the Output Option. Refer to Section 5 for an explanation of the columnar entries.

CHARACTER POSITION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

NORMAL TEMPERATURE MEASUREMENT DATA

CH	CH	SP	SP	±	SP	D	D	D	D/.	D/.	D	SP	SP	F/C	SP	!	SP	SP	CR	LF

OPEN THERMOCOUPLE OUTPUT (2190A only)

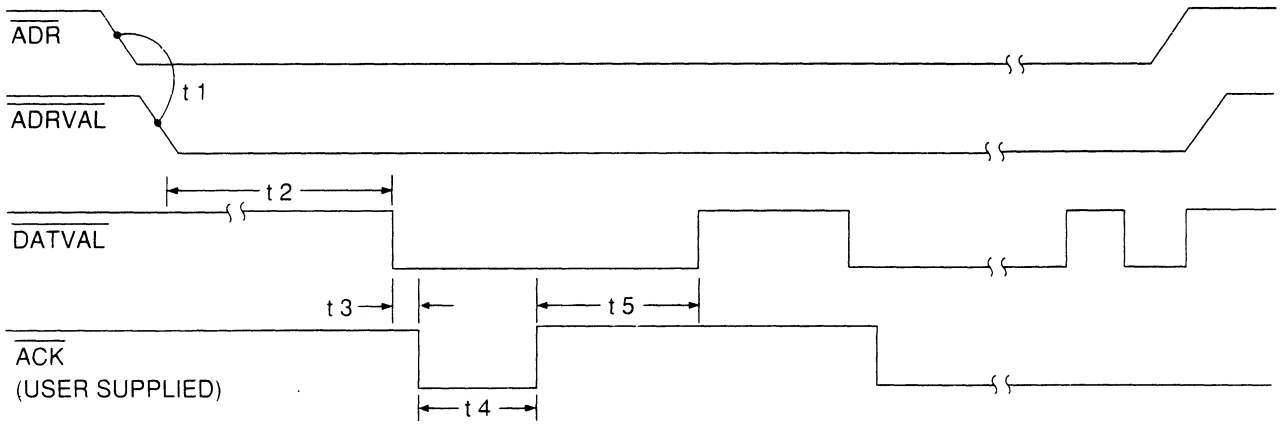
CH	CH	SP	SP	±	SP	D	D	D	D/.	D/.	D	SP	SP	F/C	SP	!	O	C	CR	LF

OVERLOAD OUTPUT

CH	CH	SP	SP	±	SP	D	D	D	D/.	D/.	D	SP	SP	F/C	SP	!	O	L	CR	LF

SYMBOL	DESCRIPTION
CH	Channel identification numbers (00 through 99, 00 unless connected to Y2000, Y2001, or 2300A).
SP	Space
+/-	Plus or minus symbol
D	Temperature data values (0 through 9) Floating decimal point, appearing in character positions 11 or 12 for the 2180A, position 12 for the 2190A.
D/.	Either a temperature data value or a decimal point
F/C	Fahrenheit or Celsius
!	Character (!) when the present limit of the Limits Option 21X0A-006 is exceeded. One space if within limits.
OC	Open (thermo)couple (character positions 18 and 19)
OL	Overload (character positions 18 and 19)
CR	Carriage Return
LF	Line Feed

Figure 602-1. Message Format



t1 1 µS max.
t2 20 µS tp 300 mS, depending upon reading cycle.
t3 0 µS min.
t4 20 µS min.
t5 20 µS typical.

Figure 602-2. Timing Diagram

Table 602-5. Option -002 Output PCB Assembly
(See Figure 602-3.)

REFERENCE DESIGNATOR -A->-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N O T -E-
A 1	*	OUTPUT UNIT ADAPTER ASSEMBLY	539288	89536	539288	1		
C 1		CAP,POLYPR,0.47UF,+-5%,100V	806265	89536	806265	1		
C 2		CAP,POLYPR,0.47UF,+-10%,50V	363085	89536	363085	1		
C 3		CAP,CER,0.22UF,+-20%,50V,Z5U	309849	71590	CW3C0C224K	1		
C 4, 6, 9-		CAP,TA,10UF,+-20%,20V	330662	56289	196D106X0020KA1	8		
C 11, 13- 15			330662					
C 5		CAP,TA,39UF,+-20%,20V	358234	56289	196D396X0020PE4	1		
C 7, 8		CAP,TA,22UF,+-20%,35V	394775	56289	196D226X0035TE4	2		
C 12, 16		CAP,TA,1UF,+-10%,35V	161919	56289	196D010X0035G	2	1	
C 17		CAP,CER,0.025UF,+-20%,100V,Z5W	168435	56289	C023B101H253M	1	1	
CR 3- 6, 11-	*	DIODE,SI,BV=75V,IO=150MA,500MW	203323	07910	1N4448	10	1	
CR 14, 16, 17	*		203323					
CR 9, 10	*	DIODE,SI,50 PIV,1.0 AMP	379412	04713	1N4933	2	1	
H 1		HARDWARE KIT (FOR J7)	435750	89536	435750	1		
H 2		WASHER,LOCK,SPLIT,STEEL,#4	110395	89536	110395	2		
H 3		NUT,HEX,S.STL,4-40	147611	89536	147611	2		
H 4		SCREW,MACH,PH,P,4-40X0.375	837690	89536	837690	2		
J 7		CONN,MICRO-RIBBON,REC,PWB EDGE,36 POS	414409	00779	552241-1	1		
J 8		INPUT JACK,FLARED	492314	89536	492314	2		
P 1		CABLE,FLAT,JMPR,4 CONDUCT,0.100 SP	474148	89536	474148	1		
P 3		CABLE,FLAT,JMPR,6 CONDUCT,0.100 SP	474155	00779	86942-5	1		
Q 2, 4, 5,	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	6		
Q 8, 9, 13	*		218396					
Q 6	*	TRANSISTOR,SI,N-JFET,REMOTE CUTOFF	429977	89536	429977	1	1	
Q 7	*	TRANSISTOR,SI,N-JFET,TO-92	343830	12040	NSSF50024	1	1	
Q 10, 11	*	TRANSISTOR,SI,BV= 80V, 10W,TO-202	495697	04713	MPS-U06	2	1	
Q 12	*	TRANSISTOR,SI,BV= 40V, 2W,TO-220	473207	01295	TIP30	1		
Q 14	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	64713	2N3906	1		
R 1- 3, 27-		RES,CF,10K,+-5%,0.25W	348839	80031	CR251-4-5P10K	12		
R 30, 32- 34,			348839					
R 48, 50			348839					
R 4, 6, 8		RES,CF,220K,+-5%,0.25W	348953	80031	CR251-4-5P220K	3		
R 5, 7, 9,		RES,CF,2.2K,+-5%,0.25W	343400	80031	CR251-4-5P2K2	4		
R 31			343400					
R 10		RES,MF,16.9K,+-1%,0.125W,100PPM	267146	91637	CMF551692F	1		
R 11		RES,VAR,CERM,25K,+-20%,0.5W	285213	11236	190PC253B	1		
R 12		RES,MF,124K,+-1%,0.125W,25PPM	479352	91637	CMF55	1		
R 13		RES,MF,2K,+-1%,0.125W,100PPM	235226	91637	CMF552001F	1		
R 14		RES,MF,750K,+-1%,0.125W,100PPM	271361	89536	271361	1	1	
R 15, 26		RES,VAR,CERM,100K,+-20%,0.5W	268581	71450	190PC104B	2		
R 16, 17		RES,MF,60.4K,+-1%,0.125W,100PPM	291419	91637	CMF556042F	2		
R 18, 20		RES,MF,3.92K,+-1%,0.125W,100PPM	294801	91637	CMF553921F	2		
R 19		RES,VAR,CERM,100,+-10%,0.5W	285130	89536	285130	1		
R 21, 22, 45		RES,MF,10K,+-1%,0.125W,100PPM	168260	91637	CMF551002F	3		
R 23, 47		RES,CF,100,+-5%,0.25W	348771	80031	CR251-4-5P100E	2		
R 24		RES,MF,1M,+-1%,0.125W,100PPM	268797	91637	CMF551004F	1		
R 25		RES,MF,1K,+-1%,0.125W,100PPM	168229	91637	CMF551001F	1		
R 35		RES,CF,5.1K,+-5%,0.25W	368712	80031	CR251-4-5P5K1	1		
R 36		RES,CF,47K,+-5%,0.25W	348896	80031	CR251-4-5P47K	1		
R 37		RES,CF,240,+-5%,0.25W	376624	80031	CR251-4-5P240E	1		
R 38		RES,CF,3.9K,+-5%,0.25W	342600	80031	CR251-4-5P3K9	1		
R 39, 41		RES,CF,6.8K,+-5%,0.25W	368761	80031	CR251-4-5P6K8	2		
R 40		RES,CF,4.3K,+-5%,0.25W	441576	80031	CR251-4-5P4K3	1		
R 42		RES,CF,3.3K,+-5%,0.25W	348813	80031	CR251-4-5P3K3	1		
R 43		RES,CF,330,+-5%,0.25W	368720	80031	CR251-4-5P330E	1		
R 44		RES,MF,1.02K,+-1%,0.125W,100PPM	223545	91637	CMF551021F	1		
R 46		RES,MF,9.09K,+-1%,0.125W,100PPM	221663	91637	CMF559091F	1		
R 49		RES,MF,4.32K,+-1%,0.125W,100PPM	294819	91637	CMF554321F	1		
R 51		RES,CF,39K,+-5%,0.25W	442400	80031	CR251-4-5P39K	1		
R 52		RES,MF,100K,+-1%,0.125W,100PPM	248807	91637	CMF551003F	1		
R 53		RES,MF,64.9K,+-1%,0.125W,100PPM	288530	91637	CMF556493F	1	2	
R 54		RES,MF,226K,+-1%,0.125W,100PPM	320879	91637	CMF552263F	1		
R 55		RES,MF,309K,+-1%,0.125W,100PPM	235283	91637	CMF553093F	1		
S 1- 3		SWITCH,DIP,SPST,4 POS	408559	00779	435166-2	3		
T 1		TRANSF,INV,MULTIPLE OUTPUT,TOROID	461954	89536	461954	1		
U 1	*	IC,CMOS,HEX BUFFER	381830	02735	CD4050AE	1	1	
U 2- 4	*	ISOLATOR,OPTO,LED TO TRNSISTOR	536045	14936	MCT-26	3	1	
U 5		RES,NET,SIP,8 PIN,7 RES,47K,+-2%	413286	89536	413286	1		
U 6	*	IC,CMOS,HEX OPEN DRAIN BUFFER	473389	12040	MM74C906N	1	1	

An * in 'S' column indicates a static-sensitive part.

Table 602-5. Option -002 Output PCB Assembly (cont)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N O T -E-
U 7	*	IC,NMOS,8 BIT MICROCOMPUTR,2190A-9403	495309	89536	495309	1		
U 8, 9	*	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	12040	MM80C97N	2	1	
U 10	*	IC,CMOS,HEX INVERTER	404681	02735	CD4069BE	1	1	
U 11, 12	*	IC,CMOS,QUAD BILATERAL SWITCH	363838	02735	CD4016AE	2	1	
U 13	*	IC,OP AMP,QUAD,JFET INPUT,14 PIN DIP	483438	89536	483438	1	1	
U 14	*	TRANSISTOR,SI,N-JFET,DUAL,TO-71	419283	89536	419283	1	1	
U 15, 21		RES,NET,SIP,6 PIN,5 RES,100K,+-2%	412726	89536	412726	2		
U 16	*	IC,CMOS,QUAD XOR GATE	355222	02735	CD4030AE	1	1	
U 17	*	IC,CMOS,DUAL 4 INPUT NOR GATE	363820	02735	CD4002AE	1	1	
U 18	*	IC,OP AMP,DUAL,JFET INPUT,8 PIN DIP	454454	02735	CA082E	1	1	
U 19	*	IC,VOLT REG,FIXED,+15 VOLTS,1.5 AMPS	413187	04713	MC7815CT	1	1	
U 20	*	IC,VOLT REG,FIXED,-15 VOLTS,1.5 AMPS	413179	04713	MC7915CP	1	1	
U 22	*	IC,COMPARATOR,DUAL,LO-PWR,8 PIN DIP	478354	12040	LM393N	1	1	
VR 1	*	ZENER,COMP, 6.4V, 2%, 2 PPM TC, 0.5MA	393579	04713	1N4567	1		
VR 7, 8	*	ZENER,UNCOMP,36.0V,5%,3.4MA,0.4W	186163	04713	1N974B	2	2	
VR 15	*	ZENER,UNCOMP,6.2V,5%,20.0MA,0.4W	325811	07910	1N753A	1	1	
X 1		SOCKET,IC,40 PIN	429282	09922	DILB40P-108	1		
Y 1	*	CRYSTAL,4MHZ,+-0.02%,HC-18/U	474072	89536	474072	1	1	

An * in 'S' column indicates a static-sensitive part.

Table 602-6. A1 Output Unit Adapter PCB Assembly
(See Figure 602-4.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N O T -E-
J 1- 6		PIN,SINGLE,PWB,0.025 SQ	376574	89536	376574	6		
Q 1, 3	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	89536	218396	2		
R 1		RES,CF,10K,+-5%,0.25W	348839	89536	348839	1		
U 1	*	IC,CMOS,DUAL D F/F,+EDG TRIG	340117	89536	340117	1		
U 2	*	IC,CMOS,HEX INVERTER	404681	89536	404681	1		

An * in 'S' column indicates a static-sensitive part.

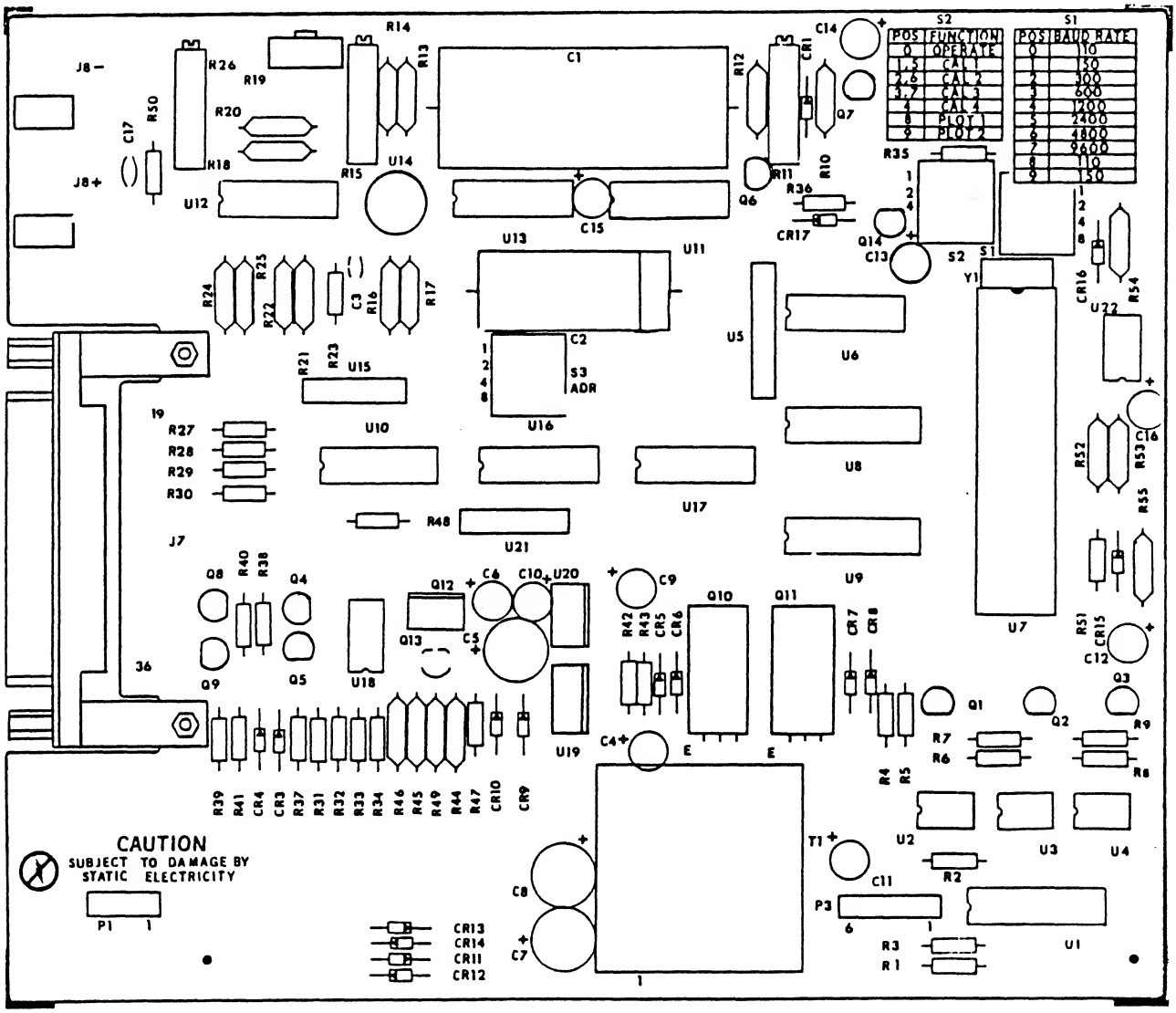
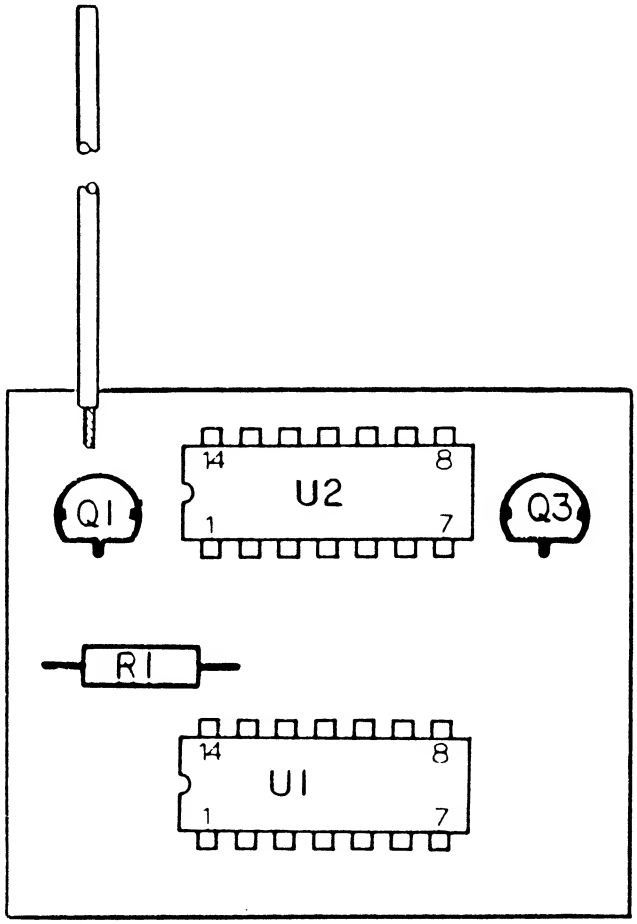


Figure 602-3. Option -002 Output PCB Assembly



2180A-1621

Figure 602-4. Output Unit Adapter Assembly

Option -004
IEEE-488 Interface

604-1. INTRODUCTION

604-2. Option 21X0A-004 IEEE-488 Interface provides the 2180A and 2190A digital thermometers with a direct output only connection to the IEEE-488 bus.

604-3. Option 21X0A-004 may be ordered with the 2180A and 2190A thermometers for factory installation, or is available by itself for service center installation. Option 21X0A-004 cannot be used in a 2300A Scanner system. For more compatibility information, refer to "Compatibility With 2300A and Previously Produced Thermometers".

604-4. The IEEE-488 standard connector is accessible from the rear panel of the thermometer. The format of the output data includes the channel number, the current reading, and any out-of-range or open thermocouple information. (Refer to Table 604-3.)

604-5. SPECIFICATIONS

604-6. Specifications for Option 21X0A-004 are shown in Table 604-1.

NOTE

The L4 listener function indicates that the thermometer IEEE-488 bus interface has the same 5-digit talk and listen addresses, and that the receipt of a listen address disables the talk address.

604-7. IEEE-488 BUS ADDRESS CODE SELECTION

604-8. A six-position dip switch (SW3), located on Option 21X0A-004 pca (printed circuit assembly), sets the IEEE-488 bus address codes for the option. To gain access to SW3, lift off the case top of the thermometer by removing the six screws from the base. Referring to Table 604-2, set positions 1 through 5 of SW3 to assign the desired address.

604-9. OPERATION

604-10. Once Option 21X0A-004 is installed and SW3 is properly set, make sure that the IEEE-488 cable is correctly connected to the option to ensure that all functions are properly monitored by the controller.

604-11. Program Considerations

604-12. Position 6 on SW3 controls the SRQ signal (Service Request) to the IEEE-488 bus. Upon receiving an SRQ, the controller serially polls each device on the bus for SRQ status. SRQ status of the Option 21X0A-004 is indicated by bit DB6 (position 64 decimal, 40 hexadecimal) in the serial poll register (U12). With SW3 position 6 in the ON position, SRQ is generated when a LF (line feed) is received in the 32-byte buffer of Option 21X0A-004. The LF character is used by the thermometer to indicate the end of a data transfer to the Option 21X0A-004. (Refer to Table 604-3.) Option 21X0A-004 sets DB1 (2 decimal), which causes a serial poll to return a total value of decimal 66 or 42 hexadecimal.

604-13. When the SRQ mode is enabled, the SRQ is set when the thermometer makes a reading available to the Option 21X0A-004. The reading is held indefinitely until the SRQ is serviced. All new readings from the thermometer are discarded. When SRQ is disabled, the output buffer is continuously updated with the most recent reading from the thermometer. However, there may be a 0.33 second delay encountered in the returned reading. This delay occurs when one reading is sent across the IEEE bus and the Option 21X0A-004 waits for the thermometer to send the next reading. An IEEE bus timeout error may occur unless the timeout is set longer than this delay.

Table 604-1. Option 21X0A-004 Specifications

ENVIRONMENTAL	
Operating Power	100, 200, 220, 240V ac ± 10% 50/60 Hz, 3VA. (The 12-volt battery operation is not supported.)
Operating Temperature	40°C (Outside ambient of thermometer.)
OPERATIONAL CONTROL	Switch 3 (SW3)
OUT-OF-LIMIT-SIGNAL	Exclamation point transmitted with Option 21X0A-006 installed only; not with Y2002.
OUTPUT	
Protocol and Connections	IEEE-488 standard

IEEE-488 Interface Function Capability Codes

IDENTIFICATION	FUNCTION	CAPABILITY
SH1	Source Handshake	Full
AH1	Acceptor Handshake	Full
T6	Talker	Serial Poll (not talk only)
L4	Listener	Not listen only (see note)
SR1	Service Request	Full
DT1	Device Trigger	Full (see 604-22. for function description)

604-14. Message Format

604-15. Table 604-3. contains the sequence of information in the output data string. The sequence is the fixed length format presented on the IEEE bus.

604-16. Sample Programs

604-17. The following sample programs show two different situations in which the controller receives temperature readings from the thermometer. The program listed in Figure 604-1 instructs the controller to asynchronously retrieve a temperature reading after an SRQ has been sent from the thermometer. The program listed in Figure 604-2 instructs the controller to ask for a temperature reading at a specific program step.

604-18. SRQ Program

604-19. The SRQ program, when typed into a 1720A, 1722A, or 1752A controller informs the controller what to do when an SRQ is received from the thermometer. The program allows the controller to perform other tasks until the thermometer has a temperature reading. The thermometer sends a 66 hexadecimal value back to the controller in response to the serial poll (SPL). If more than one thermometer or more than one other instrument (a maximum of 14) is connected to the controller, the program distinguishes which instrument is sending the SRQ and determines priority if more than one SRQ is received at the same time. After the controller receives the temperature reading and prints it on the controller screen, the program ends the SRQ handling procedure and waits for another SRQ.

NOTE

The following programs are written in Fluke BASIC and operate on the 1720A, 1722A, and 1752A controllers. A modification of the SRQ program may be required to conform to other IEEE controllers.

604-20. The Non-SRQ Program

604-21. The sample program in Figure 604-2 inputs and prints temperature readings without the use of an SRQ. A 2-second delay is required after the TRIG @2 statement (line 50) to allow Option 21X0A-004 to finish the reset process before requesting readings from it. The TIMEOUT delay (line 70) must be set greater than 333 ms, so the controller waits for the thermometer to provide the next reading to the INPUT statement.

604-22. Group Execute Trigger

604-23. The Option 21X0A-004 responds to the IEEE-488 GET command by simply resetting the two microprocessors (U5 and U11) on the board. Resetting the microp-

Table 604-2. Switch 2, IEEE-488 Bus Address Selection

ADDRESS CODES	ADDRESS SWITCH SETTINGS				
	16 (5)	8 (4)	4 (3)	2 (2)	1 (1)
0	0	0	0	0	0
1	0	0	0	0	1
2	0	0	0	1	0
3	0	0	0	1	1
4	0	0	1	0	0
5	0	0	1	0	1
6	0	0	1	1	0
7	0	0	1	1	1
8	0	1	0	0	0
9	0	1	0	0	1
10	0	1	0	1	0
11	0	1	0	1	1
12	•0	1	1	0	0
13	0	1	1	0	1
14	0	1	1	1	0
15	0	1	1	1	1
16	1	0	0	0	0
17	1	0	0	0	1
18	1	0	0	1	0
19	1	0	0	1	1
20	1	0	1	0	0
21	1	0	1	0	1
22	1	0	1	1	0
23	1	0	1	1	1
24	1	1	0	0	0
25	1	1	0	0	1
26	1	1	0	1	0
27	1	1	0	1	1
28	1	1	1	0	0
29	1	1	1	0	1
30	1	1	1	1	0

```
10 ON ERROR GOTO 250                    !Initialization
20 ON CTRL/C GOTO 260                   !       "
30 INIT PORT 0                          !       "
40 CLEAR PORT 0                         !       "
50 TRIG @2                              !Send "Group Execute Trigger" to
60                                      !reset the -004, which is arbitrarily
70                                      !set at address 2 on Port 0.
80
90 ON SRQ GOTO 140                      !Now, tell the program what to do if an
100                                     !SRQ comes.
110
120 GOTO 120                            !Most of the time it just sits here.
130
140 IF SPL(2) <> 66 RESUME              !"spl(2)" clears the SRQ. The -004 sends
150                                     !a 66(42 Hex) if it set the SRQ,
160                                     !otherwise it sends a 0. This
170                                     !discriminates between other instruments
180                                     !on the Port that could send an SRQ.
190 INPUT @2,A$                         !This command gets the thermometer reading
200                                     !from the -004.
210 PRINT A$                            !This command prints the reading.
220 RESUME                              !Ends the SRQ handling and goes to wait
230                                     !for another.
240
250 PRINT 'OOPS!!!  ERROR #';ERR;' ON LINE #'; ERL
260 PRINT 'bye-bye'
270 END
```

Figure 604-1. SRQ Sample Program

Table 604-3. Message Format

CHARACTER POSITION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

NORMAL TEMPERATURE MEASUREMENT DATA

CH	CH	SP	SP	±	SP	D	D	D	D/.	D/.	D	SP	d	F/C	SP	!	SP	SP	CR	LF

OPEN THERMOCOUPLE OUTPUT (2190A only)

CH	CH	SP	SP	±	SP	D	D	D	D/.	D/.	D	SP	d	F/C	SP	!	O	C	CR	LF

OVERLOAD OUTPUT

CH	CH	SP	SP	±	SP	D	D	D	D/.	D/.	D	SP	d	F/C	SP	!	O	L	CR	LF

SYMBOL	DESCRIPTION
CH	Channel identification numbers (00 through 99, 00 unless connected to Y2000, Y2001, or 2300A).
SP	Space
±	Plus or minus symbol
D	Temperature data values (0 through 9) for the 2180A, position 12 for the 2190A.
D/.	Either a temperature data value or a decimal point
d	a lower case (d)
F/C	Fahrenheit or Celsius
!	Character (!) when the present limit of the Limits Option 21X0A-006 is exceeded. One space if within limits.
OC	Open (thermo)couple (character positions 18 and 19)
OL	Overload (character positions 18 and 19)
CR	Carriage Return
LF	Line Feed

```
10 ON ERROR GOTO 250
20 ON CTRL/C GOTO 260
30 INIT PORT 0
40 CLEAR PORT 0
50 TRIG @2
60 WAIT 2000                          !Wait for -004 to finish reset process
70 TIMEOUT 350                        !Set IEEE timeout longer than reading delay
190 INPUT @2,A$                       !Request a reading
210 PRINT A$
220 GOTO 190
250 PRINT 'OOPS!!!  ERROR #';ERR;' ON LINE #';ERL
260 PRINT 'bye-bye'
270 END
```

Figure 604-2. Non-SRQ Sample Program

rocessors ensures that they are synchronized properly with the IEEE-488 interface chip (U12), and is a recommended start-up procedure at the beginning of the program in the IEEE-488 controller. A 2 second time delay is required to complete the resetting operation. Do not attempt to access Option 21X0A-004 before the end of the time delay.

604-24. Functional Equivalent

604-25. The operation of Option 21X0A-004 is functionally equivalent to the combination of the Fluke 21X0A-002, 2XXXA-522, and 1120A with the exception of the following four items:

CHANGES:

1. Option 21X0A-004 displays a lower case (d) instead of a blank in front of the temperature scale indicator. See Output Format, Table 604-3.

2. Option 21X0A-004 operates at the full speed rate of the thermometer, (3 readings per second, instead of 1.5 readings per second).

3. The 2XXXA-522 previously contained a buffer-full SRQ function that produced an SRQ when the 32-byte buffer is filled. The buffer-full SRQ function no longer exists with the 2XXXA-522, but the switch is still present and its function is still listed in the 2XXXA-522 manual. The buffer-full SRQ function is not available on Option 21X0A-004.

ADDED
FEATURE:

4. Option 21X0A-004 responds to a Group Execute Trigger. See Group Execute Trigger, paragraph 604-23.

604-26. If you include Option 21X0A-004 when upgrading or adding new equipment to a system currently operating with the 21X0A-002, 2XXXA-522, or 1120A combination, note the first two changes listed in paragraph 604-25.

604-27. THEORY OF OPERATION

604-28. Option 21X0A-004 converts the temperature displayed by the thermometer into a format usable by an IEEE-488 Bus Controller. Option 21X0A-004 communicates with the thermometer on the clocked bit-serial accessory bus. The channel number, range, conversion type, scale, and digits of the temperature reading are transmitted on the bus. The cycle is repeated every 333 ms. When the Write Address (WRTADR-) line is held low, Data Clock (DCLK-) clocks the accessory bus address then the thermometer data into the 3870 microprocessor (U5) on the DATA- line. In U5, the data is formatted (Table 604-2) and made available for transfer to the 8748 microprocessor (U11).

604-29. U5 applies a character to the tri-state buffers (U8 and U9) and pulls the Data Valid (DATVAL) line low. If U11 is not transferring data to U12 or if it is waiting for SRQ to be serviced, U11 responds to U5 by strobing the character onto the Option Data Bus with a STROBE- signal and reads the character into its 32-byte buffer. U11 also generates Acknowledge (ACK), which causes U5 to reply with a new character. When an LF character is detected, U11 unmasks the byte-out interrupt. If the SRQ switch is set to ON, the SRQ switch triggers the GPIA (General Purpose Interface Adapter) to send SRQ to the controller. The 32-byte buffer never completely fills because thermometer readings consist of 21 bytes.

604-30. The IEEE-488 Bus Controller initiates the talk mode by sending the talk address to the GPIA (U12) over the IEEE-488 bus when Attention (ATN) is asserted true low. The GPIA responds by setting the byte-out interrupt (U12-40) high, as a signal to U11 to pass data bytes to U12. The following three conditions must be met before data transfer can begin:

- Ready For Data (RFD) from the IEEE-488 bus is true (low).
- Data Accepted (DAC) from the IEEE-488 bus is false (high).
- U11 must have the byte-out interrupt unmasked.

604-31. When the above conditions are met, U11 sends the data byte to the Data Out Register of the GPIA via the Option Data Bus. At this time, the byte-out interrupt is set to zero, and the data byte is checked for the LF character. The GPIA handshakes the data byte to the IEEE-488 Bus, and the byte-out interrupt (U12-40), transmitted to U11, is set to 1. If the data byte is an LF character, EOI (End or Identify) is also sent to the IEEE Controller to signal the end of a data reading. This process continues as long as there is data in the 32-byte buffer of U11. When the 32-byte buffer is empty, U11 masks the byte-out interrupt from the GPIA.

604-32. The IEEE-488 address setting for Option 21X0A-004 is read by the GPIA (U12) via the Option 21X0A-004 data bus when the GPIA sends a strobe out on U12-4 to the address switch tri-state buffers (U18).

604-33. When the GPIA detects a Group Execute Trigger for its address, it sets U12-24 to a logic high to cause a

Power On Reset (POR) via Q4 and U16. The POR resets U5 and U11, and lasts for approximately 150 ms.

604-34. The power supply for Option 21X0A-004 power supply is a standard linear regulator using a full-wave center tap rectifier and pass transistor regulator (Q5). The regulator is driven by U17 and Q6, and is referenced from a 2.5-volt band gap reference (U15). U16 performs POR and low voltage detection. The option provides its own power rather than using the power supply of the thermometer, which is unable to provide enough additional power.

604-35. Option 21X0A-004 is a consolidation of the circuitry from Option 21X0A-002, Option 2XXXA-522, and 1120A that is required for IEEE-488 output operation. The consolidated circuitry does not include analog output capability or the slow serial communication link between the Option 21X0A-002 and 2XXXA-522 microprocessors. Instead, the circuitry uses the PTI (Portable Test Instrument) parallel output port of the Option 21X0A-002 to communicate with the Option 2XXXA-522 microprocessor.

604-36. COMPATIBILITY WITH 2300A AND PREVIOUSLY PRODUCED THERMOMETERS

604-37. Option 21X0A-004 is not intended to be used with a thermometer that is a part of a 2300A Scanning System. In a 2300A system, an Option 2300A-005 or Option 2300A-006 should be installed in the 2300A for connection to the IEEE-488 bus. Option 2300A-005 is for output only, similar to Option 21X0A-004 operation. Option 2300A-006 additionally provides remote control of the 2300A. Options 2300A-005 and 2300A-006 use the 2XXXA-522 and 1120A for connection to the IEEE bus.

CAUTION

Option 21X0A-004 is not compatible with a 2300A Scanning System. Such use may cause channel numbers to be displaced by one reading, and each reading may be output twice.

604-38. Option 21X0A-004 is not directly compatible with the earliest version of the 2180A and 2190A thermometers. A choice of either of the two modifications described below provides compatibility. To identify the early version of thermometer, observe the thermometer display as it is turned on. If the display characters begin with "2180" or "2190", the thermometer is an early version. Newer versions begin with "800" or "900."

604-39. If your thermometer is an early version, either of the following two modifications may be performed:

1. The microprocessor in the thermometer can be replaced with a newer version. Contact your local John Fluke Service Center to order the latest 2180A or 2190A standard versions.

   a. When you are updating a 2180A to the latest version, be aware there are changes in the available choice of Resistance Temperature Detector (RTD) linearizations. If you require the original linearizations, order a special retrofit kit Model 2180A/AYK. (P/N 796953)

   b. When you are selecting from the latest versions of 2190A linearizations, be aware that an enhanced microprocessor retrofit kit is also available. The enhanced retrofit kit provides 15 thermocouple types. Order Model 2190A/AMK (P/N 763292)

2. A modification to Option 21X0A-004 may alternatively be performed. Contact your local John Fluke Service Center and arrange for the installation of a 2180A-4021W (JF P/N 539288) onto Option 21X0A-004. Q1 and Q3 are removed from the pca and replaced by the modification circuit. This modification makes Option 21X0A-004 compatible with all versions of 2180A and 2190A thermometers. A +5 volt connection is provided next to U2 to provide power to the added modification circuit.

604-40. PERFORMANCE TEST

604-41. There are no adjustments or calibration.

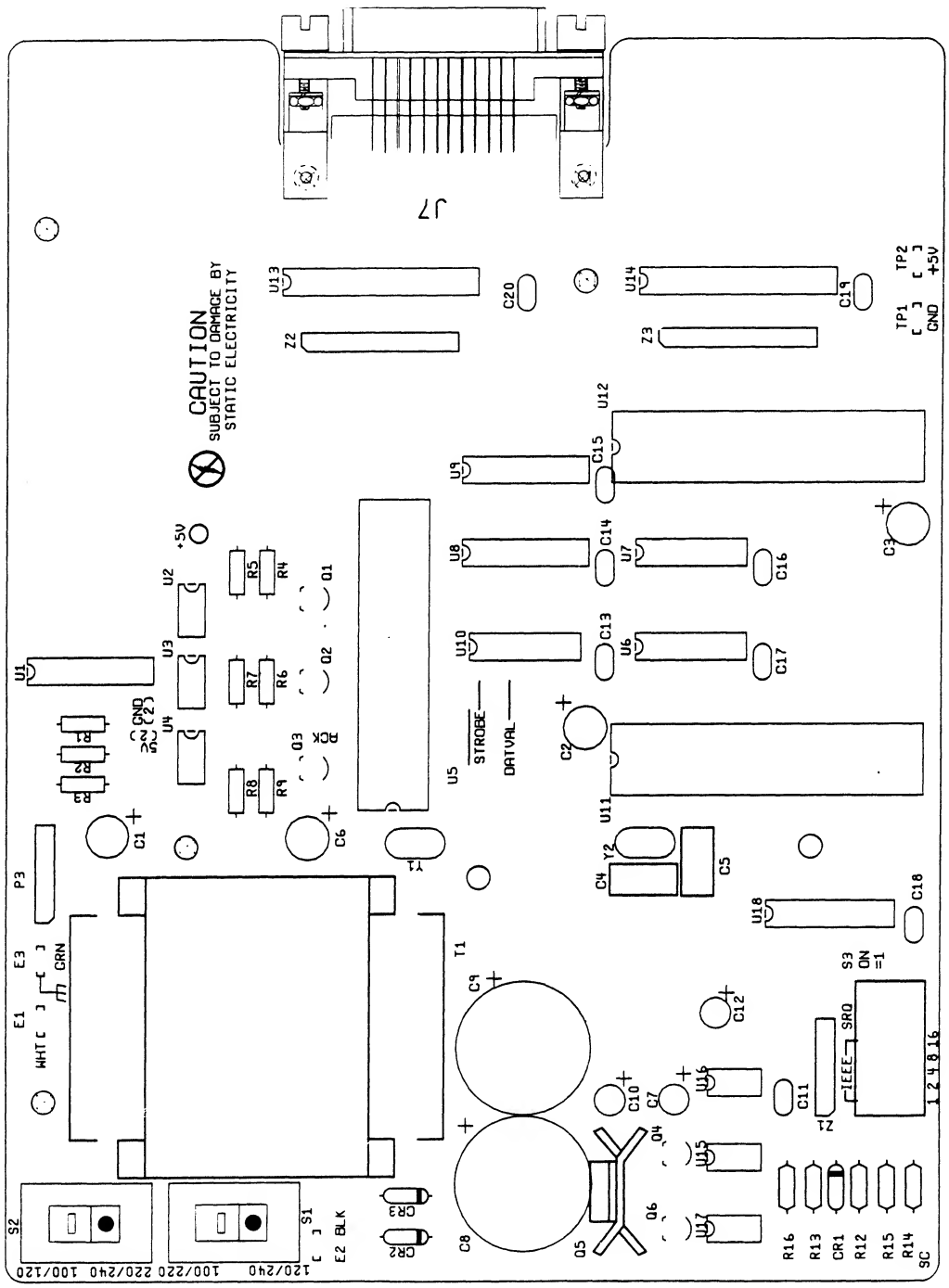
604-42. With Option 21X0A-004 attached to a 2180A or 2190A thermometer, apply proper ac input voltage and measure for 5.05 ± 0.1 volts dc across TP1 and TP2.

604-43. Connect Option 21X0A-004 to an IEEE-488 controller via the IEEE-488 bus. Execute the SRQ program in Figure 604-1 to retrieve readings from Option 21X0A-004

Table 604-5. Option -004 IEEE-488 Interface PCB Assembly
(See Figure 604-3.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N O T -E-
C 1, 2, 3,		CAP,TA,10UF,+-20%,20V	330662	56289	196D106X0020KA1	4		
C 6			330662					
C 4, 5		CAP,MICA,22PF,+-5%,500V	148551	02799	DM15C220J	2		
C 8, 9		CAP,AL,3300UF,+30-10%,16V,SOLV PROOF	603472	89536	603472	2		
C 10, 12, 16		CAP,TA,1UF,+-10%,35V	161919	56289	196D010X0035G	3		
C 11, 13- 20		CAP,CER,0.22UF,+-20%,50V,Z5U	519157	51406	RPE111Z5U224M50V	9		
CR 1	*	DIODE,SI,BV=75V,IO=150MA,500MW	203323	07910	1N4448	1		
CR 2, 3	*	DIODE,SI,100 PIV,1.5 AMP	116111	05277	1N4817	2	1	
E 1, 2, 3		TERM,FASTON,TAB,SOLDR,0.110 WIDE	512889	02660	62395	5	1	
H 1		SCREW,MACH,SEMS,PH,P,STL,6-32X0.375	177022	89536	177022	2		
H 2		NUT,HEX,S.STL,4-40	147611	89536	147611	2		
H 3		SCREW,MACH,PH,P,4-40X0.375	837690	89536	837690	2		
H 4		SCREW,CONNECTOR MOUNTING	429472	89536	429472	2		
H 5		NUT,MINI,HEX,SS,6-32	110569	89536	110569	2		
H 6		HARDWARE KIT (FOR J7)	435750	89536	435750	1		
H 7		WASHER,LOCK,SPLIT,STEEL,#4	110395	89536	110395	2		
J 7		CONN,MICRO-RIBBON,REC,PWB EDGE,24POS	484220	89536	484220	1		
MP 1		SPACER,POLY-E,SW-STANDOFF HT,0.063	285346	89536	285346	2		
MP 2		SHIELD, IEEE I/F ASSY.	795427	89536	795427	1		
P 3		CABLE,FLAT,JMPR,6 CONDUCT,0.100 SP	474155	00779	86942-5	1		
Q 1- 4, 6	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	5	1	
Q 1		RIVET,PUSH,BI,NYL,0.118X0.217	745869	89536	745869	1		
Q 2		HEAT DIS,VERT MT,1.25X0.875,TO-220	524934	13103	6025B-TT	1		
Q 5	*	TRANSISTOR,SI,BV= 40V, 2W,TO-220	473207	01295	TIP30	1	1	
R 1, 2, 3		RES,CF,10K,+-5%,0.25W	348839	80031	CR251-4-5P10K	3		
R 4, 6, 8		RES,CF,220K,+-5%,0.25W	348953	80031	CR251-4-5P220K	3		
R 5, 7, 9		RES,CF,2.2K,+-5%,0.25W	343400	80031	CR251-4-5P2K2	3		
R 12		RES,MF,226K,+-1%,0.125W,100PPM	320879	91637	CMF552263F	1		
R 13		RES,MF,309K,+-1%,0.125W,100PPM	235283	91637	CMF553093F	1		
R 14		RES,MF,10.2K,+-1%,0.125W,100PPM	293605	91637	CMF551022F	1		
R 15		RES,MF,10K,+-1%,0.125W,100PPM	168260	91637	CMF551002F	1		
R 16		RES,CF,100,+-5%,0.25W	348771	80031	CR251-4-5P100E	1		
S 1, 2		SWITCH,SLIDE,DPDT,POWER	234278	89536	234278	2		
S 3		SWITCH,DIP,DPST,PIANO,6 POS	800037	89536	800037	1		
T 1		5 VOLT TRANSFORMER	747881	89536	747881	1		
U 1	*	IC,CMOS,HEX BUFFER	381830	02735	CD4050AE	1	1	
U 2, 3, 4	*	ISOLATOR,OPTO,LED TO TRANSISTOR	380014	01295	T1L116	3	1	
U 5	*	IC,NMOS,8 BIT MICROCOMPUTR,2190A-9403	495309	89536	495309	1		
U 6	*	IC,LSTTL,QUAD 2 INPUT NAND GATE	393033	01295	SN74LS00N	1	1	
U 7	*	IC,LSTTL,HEX INVERTER	393058	01295	SN74LS04N	1	1	
U 8, 9, 18	*	IC,CMOS,HEX BUFFER W/3-STATE OUTPUT	407759	12040	MM80C97N	3	1	
U 10	*	IC,LSTTL,DUAL D F/F,+EDG TRG,W/CLR	393124	01295	SN74LS74N	1	1	
U 11	*	IC,NMOS,8 BIT MICROCOMPTR,1KX8 EPROM	454652	34649	C8748	1		
U 12	*	IC,NMOS,GEN PURPOSE INTERFACE ADAPTOR	477794	04713	MC68488P	1	1	
U 13, 14	*	IC,LSTTL,OCTL IEEE-488 BUS TRANSCVR	524835	04713	MC3447P	2	1	
U 15	*	IC, 2.5 V,40 PPM T.C.,BANDGAP REF	472845	04713	MC1403V	1	1	
U 16	*	IC,COMPARATOR,DUAL,LO-PWR,8 PIN DIP	478354	12040	LM393N	1	1	
U 17	*	IC,OP AMP,SELECTED DIFF OUT VOLT=2MV	473777	89536	473777	1	1	
XU 5, 11, 12		SOCKET,IC,40 PIN	429282	09922	DILB40P-108	3	1	
Y 1	*	CRYSTAL,4MHZ,+-0.02%,HC-18/U	474072	89536	474072	1	1	
Y 2	*	CRYSTAL,6MHZ,+-0.01%,HC-18/U	461665	89536	461665	1	1	
Z 1		RES,NET,SIP,6 PIN,5 RES,100K,+-2%	412726	89536	412726	1		
Z 2, 3		RES,NET,SIP,10 PIN,9 RES,100K,+-2%	461038	80031	95081002CL	2		

An * in 'S' column indicates a static-sensitive part.



CAUTION
SUBJECT TO DAMAGE BY
STATIC ELECTRICITY

WARNING: ⊗ INDICATES USAGE OF MOS DEVICE(S) WHICH MAY BE DAMAGED BY STATIC DISCHARGE. USE SPECIAL HANDLING PER S.O.P. 19.1

21X0A-1601

Figure 604-3. Option -004 IEEE-488 Interface PCB Assembly

Option -006
Limits

606-1. INTRODUCTION

606-2. The 21X0-006 Limits Option gives the 2180A and 2190A Digital Thermometers the capability of providing both visual and electrical indications (alarms) when the temperature measurement exceeds either of a pair of selectable maximum/minimum limit values. Also selectable are, all for a single point, the delta function (displays the difference between the preset value and the temperature read), and the maximum/minimum display function (the highest or lowest temperature read since the last reset by the INITIALIZE MAX/MIN switch).

606-3. The Limits Option is available as factory installed with initial order or may be ordered as a field installable kit for addition to the instrument.

606-4. SPECIFICATIONS

606-5. Specifications for the Limits Option, 21X0-006, are as listed in Table 606-1.

Table 606-1. Specifications

Limits Function: lights LED and activates Form A (SPST) relay when a preset limit is exceeded. Contacts rated at 10 VA, 184V dc or 130V ac rms max, 0.5A max, resistive.
Min/Max Function: Store min or max readings, resettable from front panel.
Δ Temperature Function: Reads ± temperature deviations from preset nominal temperature.
Installable: Factory or field, through pre-punched front panel.

Function:	**Limit:**
≤ Low Limit	−9999°
> High Limit	+9999°
Store min reading	Not used
Store max reading	Not used
Δ ± Deviation from	Nominal

606-6. INSTALLATION

606-7. Options for field installation can be installed using the following procedure:

WARNING

HAZARDOUS VOLTAGES MAY BE PRESENT WITHIN THE INSTRUMENT. ONLY QUALIFIED PERSONNEL SHOULD PERFORM THIS INSTALLATION PROCEDURE.

1. Disconnect the thermometer from all power sources.

2. Remove the screws on the bottom of the case that fasten the top and bottom of the PTI case together and remove the top half of the case.

3. Remove the hole plugs from the Limits section of the front panel and attach the standoffs supplied with the option to the front panel.

4. Position the Limits PCB so that the thumbwheel LED and pushbutton switch line up with the applicable front panel ports.

5. Attach the Limits PCB to the Main PCB using the screws supplied with the option.

6. Connect the cable on the Limits PCB to J4 on the Main PCB.

7. Replace the PTI cover on the instrument and reconnect to input power sources, if required at this time.

606-8. OPERATING NOTES

606-9. Installation of the Limits Option enables the low current single contact relay (K1) on the thermometer Main PCB. The contact points are available on a rear panel connector block.

NOTE

Once installed there are no provisions for disabling the Limits Option. If a temperature display is desired without the relay or LED indications select one of the Limits Functions (> or ≠) and the maximum setting on the numeric thumbwheel switches.

606-10. OPERATION

606-11. The position and general description of the Limits Option front panel controls is given in Section 2. A more detailed description of the three functions is given in the following paragraphs.

606-12. Limits Function

606-13. The limits function is enabled when the function portion of the thumbwheel is set in either the ≤ or > position. The front panel LED illuminates and the rear panel relay contacts close when either of the preset conditions are met. In the greater than (>) function the indications (LED and relay contacts) result from any temperature reading that exceeds the value set on the limit thumbwheel. The less than (≤) function gives its indication when the temperature read by the thermometer is equal to, or less than, the value set on the limit thumbwheels. The thumbwheel LSD is a whole number, fractional entries cannot be made.

606-14. Delta Function

606-15. When the delta (△) function is selected on the thumbwheel the thermometer display reads the difference between the temperature at the thermocouple and the whole number setting of the thumbwheels. The formula used for the computation is:

T displayed = T at thermocouple - T thumbwheel setting (in degrees)

606-16. MINIMUM/MAXIMUM Display Function

606-17. The microcomputer acculmulates and stores the highest and lowest temperatures recorded since the last reset. When the maximum (⤒) function is selected the highest temperature recorded and stored in the microcomputer is displayed. Selection of the minimum function (⤓) displays the lowest recorded temperature since the last reset. To record the current temperature for either function, select the applicable function and depress the front panel reset switch.

606-18. THEORY OF OPERATION

606-19. The -006 Option supplies the thermometer with the function and numeric data selected on the front panel mechanical thumbwheel switches. When a Limits function is selected the data is stored for comparison on the option pcb. All communication between the option and the thermometer is done on the clocked serial accessory bus. This bus transmits and receives addresses, thumbwheel data, reset data, and limit status. Refer to the schematic in Section 8 during the Theory of Operation discussion.

606-20. Addressing

606-21. Each of the options on the bus is addressed with a different code. The thermometer uses the address "6" to talk to the Limits Option. To talk to any option, the $\overline{\text{WRTADR}}$ (P4-3) line must be brought low with $\overline{\text{WRT}}$ (P4-4) high, followed by the applicable four address bits applied to the $\overline{\text{DATA}}$ (P4-5) line in succession, toggling $\overline{\text{DCLK}}$ (P4-6) for each bit. This clocks the address into the shift register (U2-15) where it is compared to the Limits Option address and, if valid, (U1-1 low) enables the gates required to shift data to the thermometer (U5-11) and into the limits option (U5-2). Details of the data transfer are in subsequent paragraphs.

606-22. Limits Option Outputs

606-23. Before the thermometer can input data from the Limits Option the Limits circuitry must be addressed as described previously (U1-1 low). Once addressed, the $\overline{\text{WRTADR}}$ and $\overline{\text{WRT}}$ lines go high. The low to high transition of $\overline{\text{WRTADR}}$ (U3-6) loads the shift registers from the thumbwheel and RESET switches. The two lines enable the output data line (U1-13) and as the the thermometer accepts the data it clocks the serial output shift registers with $\overline{\text{DCLK}}$, transferring the data from the shift register to the thermometer.

606-24. In the thermometer the data is processed by the microcomputer to perform the proper action. For the limits function, the output is compared to the state of the limits and, if exceeded, the indicator illuminated and the relay energized. For the delta function, the temperature is compared against the transmitted value and the difference displayed. If either the maximum or minimum function is selected the stored value is displayed, but, in addition, the status of the RESET switch is checked.

606-25. Limits Option Inputs

606-26. The thermometer transmits to the Limits Option only the limits exceeded status. After the option

has been addressed, (U1-1) $\overline{\text{WRTADR}}$ goes high to disable the addressing circuit (U4-13), while $\overline{\text{WRT}}$ stays low to enable the limits exceeded input (U5-8) so that $\overline{\text{DCLK}}$ can clock the data into the latch (U5-1). A limits exceeded indication clocks a high into the latch resulting in a low at the output (U6-12) to turn on CR1. The limits not exceeded or another function selected, loads a low into the latch to turn off the indicator.

606-27. CALIBRATION

606-28. The Limits Option has no variable components and does not require calibration.

606-29. TROUBLESHOOTING

606-30. Troubleshooting for the 2190A Option -006, Limits, consists of the tabular flow chart in Table 606-2. When a step on the flow chart is completed, check for a decision transfer. If no decision is required, perform the next step of the table in sequence.

606-31. LIST OF REPLACEABLE PARTS

606-32. Table 606-3 is a list of replaceable parts for the Limits Option. Refer to Section 5 for an explanation of the columnar entries.

Table 606-2. Limits Option Troubleshooting

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
	NOTE *These tests are based on the assumption that the 2180A/2190A has been thoroughly checked out and is free of troubles prior to beginning the test of the Limits Option –006.*		
1	Select the less than or equal function (≤) and set the thumbwheels for a numeric such that the thermocouple input exceeds the preset numeric (e.g., thumbwheels set at +1111 and the ambient temperature used as the thermocouple input).		
2	Does the LIMIT indicator illuminate and the rear panel relay contacts close?	26	3
3	Is the +5V dc input from the Main PCB present?	5	4
4	Check the +5 Vdc input, repair as required then resume at Step 1.		
5	Does the signal at U1-1 toggle (vary between logic high and logic low) when viewed with a scope?	13	6
6	Do the $\overline{\text{WRT}}$, $\overline{\text{WRTADR}}$ and $\overline{\text{DCLK}}$ lines toggle?	8	7
7	Check the inputs on the cable from the microcomputer on the Main PCB. Repair as required then resume at Step 1.		
8	Does the $\overline{\text{DATA}}$ line toggle?	10	9
9	Check the cabling and Q1, Q2, U3-8 and their associated components. Repair as required then resume at Step 1.		
10	Are the clock and data signals present at pins 1 and 15 of U2, respectively?	12	11
11	Check U1, U2-2, 11, 12, 13 and U3. Repair as required then resume at Step 1.		
12	Check U4 for the clock and U6 for loading of the data line. Repair as required then resume at Step 1.		
13	Is the function code (≤) a BCD 0 with pins 4, 5, and 6 of U7 low, the sign (+) at U7-7 high, the numeric MSD BCD code as set at pins 1, 15, 14 and 13 of U9, the second MSD BCD code as set at pins 4, 5, 6, and 7 of U11?	15	14
14	Check the switches and their associated components. Reapir as required then resume at Step 1.		
15	Is the clock present at U7-10, U9-10, and U11-10?	17	16
16	Check U4-10, U1-13 and their inputs. Repair as required then resume at Step 1.		

Table 606-2. Limits Option Troubleshooting (cont)

STEP NO.	ACTION	Go to the step number given for correct response	
		YES	NO
17	Does the signal at U11-3, U9-3, and U7-3 toggle?	19	18
18	Check U11, U9, and U7. Repair as required then resume at Step 1.		
19	Does the $\overline{DATA}$ line toggle?	21	20
20	Check Q1, Q2, U3, U5-10 and their associated components. Repair as required then resume at Step 1.		
21	Are the clock and data signals present at pins 11 and 9 of U6, respectively?	23	22
22	Check U5 for the clock, repair as required then resume at Step 1.		
23	Is the collector of Q9 low?	25	24
24	Check Q9, Q3, U6-12 and their associated components. Repair as required then resume at Step 1.		
25	Check the indicator CR1 and the relay on the Main PCB. Repair as required then resume at Step 1.		
26	Set the FUNCTION switch to greater than (>) and input a temperature from the thermocouple that exceeds the preset limit.		
27	Does the LIMIT indicator illuminate and the relay contacts close?	29	28
28	Check for a Function BCD code of 1 (001) at pins 4, 5, and 6 of U7. The sign at U7-7 is high for plus and low for minus. Check that the thumbwheel switches reflect the BCD codes set on them. Repair as required then resume at Step 1.		
29	Set the FUNCTION switch to the Delta (△) position and set the thumbwheels to the desired base.		
30	Is the difference between the thermocouple input and the preset base displayed?	32	31
31	Check for a Function of BCD code of 2 (010) at pins 4, 5, and 6 of U7. Check that the thumbwheel switches reflect the BCD codes set on them. Repair as required then resume at Step 29.		
32	Set the FUNCTION switch to the minimum (⤓) position and depress the INITIALIZE MIN/MAX switch.		
33	Does the thermometer display reflect the lowest temperature input from the thermocouple since the switch was depressed?	35	34
34	Check for a Function BCD code of 3 (011) at pins 4, 5, and 6 of U7. Check U2-4 and 5, U4-3 and 4, U6-1, the initialize switch S7 and their associated components. Repair as required then resume at Step 32.		
35	Set the FUNCTION switch to the MAXIMUM (⤒) position and depress the INITIALIZE MIN/MAX switch.		
36	Does the thermometer display reflect the highest temperature input from the thermocouple since the switch was depressed?	38	37
37	Check for a Function BCD code of 4 (100) at pins 4, 5, and 6 of U7. Repair as required then resume at Step 35.		
38	Troubleshooting of the 21X0-006 Limits Option is complete.		

Table 606-3. Option -006 Limits PCB Assembly
(See Figure 606-1.)

REFERENCE DESIGNATOR -A->-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	RS -Q	NOT -E-
CR 1	*	LED,RED,PCB MOUNT,LUM INT= >0.6 MCD	385914	09214	SSL-22	1		
H 1		SCREW,MACH,PH,PSTL,6-32X0.500	152173	89536	152173	2		
H 2		SCREW,MACH,SEMS,PH,P,STL,6-32X.500	177030	89536	177030	2		
MP 1		ACTUATOR, SWITCH	412106	89536	412106	1		
MP 2		COVER, PUSHBUTTON SWITCH	401299	89536	401299	1		
MP 3		BUTTON	472332	89536	472332	1		
MP 4		ASSY, LED STANDOFF	472548	89536	472548	1		
MP 5		SPACER,RND,S STEEL,0.143IDX0.250	484865	89536	484865	2		
P 4		CABLE,FLAT,JMPR,7 CONDUCT,0.100 SP	474379	00779	86946-6	1		
Q 1	*	TRANSISTOR,SI,PNP,SMALL SIGNAL	195974	64713	2N3906	1	1	
Q 2, 3, 9	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	64713	2N3904	3		
R 1- 4, 6,		RES,CF,10K,+-5%,0.25W	348839	80031	CR251-4-5P10K	6		
R 8			348839					
R 5		RES,CF,100K,+-5%,0.25W	348920	80031	CR251-4-5P100K	1		
R 7		RES,CF,240,+-5%,0.25W	376624	80031	CR251-4-5P240E	1		
R 9		RES,CF,20K,+-5%,0.25W	441477	80031	CR251-4-5P20K	1		
R 10		RES,CF,2.2K,+-5%,0.25W	343400	80031	CR251-4-5P2K2	1		
S 1		SWITCH,ROTARY,MULT POS,SPECIAL,6THUMB	472803	89536	472803	1		
S 2		SWITCH PART,SPST,SPRING	414516	00779	63212	1		
S 3		SWITCH PART,SPST,FIXED CONTACT	416875	00779	62313	1	1	
U 1	*	IC,CMOS,DUAL 4 INPUT NAND GATE	355206	04713	NM14012CP	1	1	
U 2	*	IC,CMOS,DUAL,4BIT SER-IN,PAR-OUT SHFT	340125	04713	MC14015CP	1	1	
U 3	*	IC,CMOS,HEX INVERTER	404681	02735	CD4069BE	1	1	
U 4	*	IC,CMOS,QUAD 2 INPUT NOR GATE	355172	02735	CD4001AE	1	1	
U 5	*	IC,CMOS,TRIPLE 3 INPUT NOR GATE	355180	02735	CD4025AE	1	1	
U 6	*	IC,CMOS,DUAL D F/F,+EDG TRIG	340117	02735	CD4013AE	1	1	
U 7, 9, 11	*	IC,CMOS,DUAL D F/F,+EDG TRIG	380766	02735	CD4021AE	3	1	
U 8, 10, 12		RES,NET,SIP,8 PIN,7 RES,100K,+-2%	412908	89536	412908	3	1	

An * in 'S' column indicates a static-sensitive part.

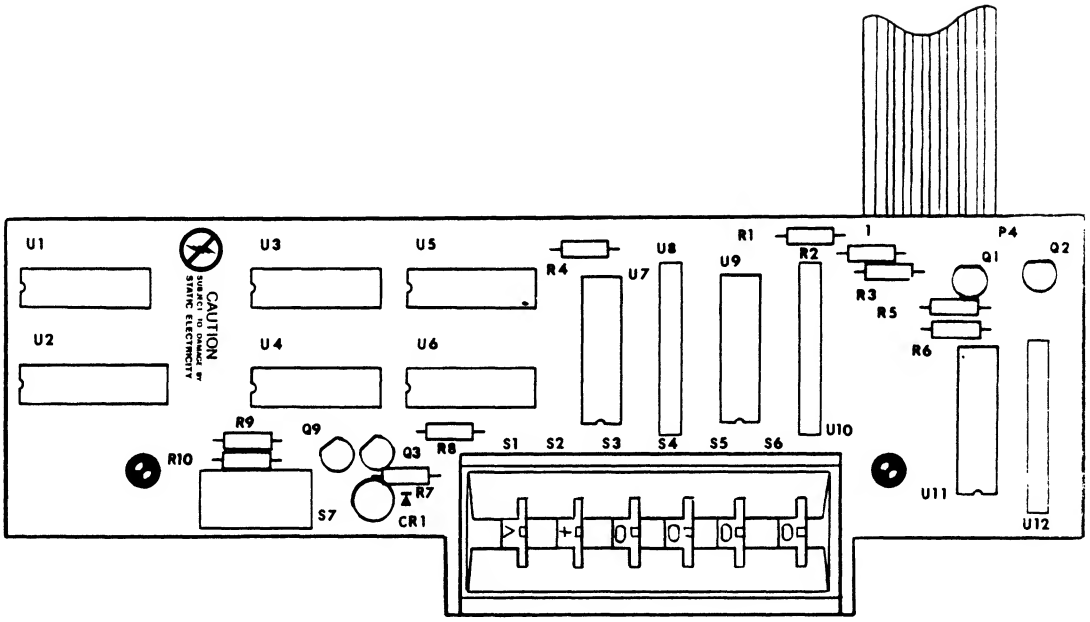


Figure 606-1. Option -006 Limits PCB Assembly

Section 7
General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable Parts contained in Section 5.

Federal Supply Codes for Manufacturers

D9816
Westermann Wilhelm Augusta-Anlage
Mannheim-Nackarau Germany

S0482
Sony Corp.
Tokyo, Japan

S3774
Oshino Electric Lamp Works
Tokoyo, Japan

0AD86
IN General
El Paso, TX

0AE89
Autosplice Inc.
Woodside, NY

0BW21
Noritake Co. Inc.
Burlington, MA

0ANF0
Topaz Semiconductor Inc
San Jose, CA

0DSM7
Conductive (Pkg) Containers Inc.
Brookfield, WI

0CLN7
Emhart Fastening Group
Shelton, CT

0FB81
S-Mos Systems Inc.
San Jose, CA

0FFP1
Eveready LTD
Ever Ready Special Battery Div.
Dawley Telford Salop UK

00199
Marcon Electronics Corp
Keamy, NJ

00213
Nytronics Comp. Group Inc.
Darrlingon, NC

00327
Welwyn International Inc.
Westlake, OH

00656
Aerovox Corp.
New Bedford, MA

00686
Film Capacitors Inc.
Passaic, NJ

00779
AMP, Inc.
Harrisburg, Pennsylvania

00853
Sangamo Weston Inc
Components Div
Pickens, NC

01091
Allied Plastics Co.
Los Angeles, CA

01101
Wabash Inc
(Formerly Wabash Magnetics)
Wabash, IN

01121
Allen Bradley Co.
Milwaukee, WI

01281
TRW Electronics & Defense Sector
R F Devices
Lawndale, CA

01295
TX Instruments Inc.
Semiconductor Group
Dallas, TX

01526
Genicom
Waynesboro, VA

01537
Motorola Communications &
Electronics Inc.
Franklin Park, IL

01686
RCL Electronics/Shallcross Inc.
Electro Components Div.
Manchester, NH

01884
Sprague Electric Co.
(Now 56289)

01961
Varian Associates Inc.
Pulse Engineering Div.
Convoy, CT

01963
Cherry Electrical Products Corp
Waukegan, IL

02111
Spectrol Electronics Corp.
City of Industry, CA

02114
Amperex Electronic Corp.
Ferrox Cube Div.
Saugerties, NY

02131
General Instrument Corp.
Government Systems Div.
Westwood, MA

02395
Sonar Radio Corp.
Hollywood, FL

02533
Leigh Instruments Ltd.
Frequency Control Div.
Don Mills, Ontario, Canada

02606
Fenwal Labs
Division of Travenal Labs
Morton Grove, IL

02660
Bunker Ramo-Eltra Corp.
Amphenol NA Div.
Broadview, IL

02697
Parker-Hannifin Corp.
O-Ring Div
Lexington, KY

02735
RCA-Solid State Div.
Somerville, NJ

02768
ITW (IL Tool Works)
Fastex Division
Des Plaines, IL

02799
Arco Electronics Inc.
Chatsworth, CA

03296
Nylon Molding Corp.
Monrovia, CA

03445
Lercon Electronics Inc
Burbank, CA

03508
General Electric Co.
Semiconductor Products
& Batteries
Auburn, NY

03797
Genisco Technology Corp.
Eltronics Div.
Rancho Dominquez, CA

03877
Gilbert Engineering Co.Inc
Incon Sub of Transitron
Electronic Corp.
Glendale, AZ

03888
KDI Electronics Inc.
Pyrofilm Div.
Whippany, NJ

03911
Clairex Corp.
Clairex Electronics Div.
Mount Vernon, NY

03980
Muirhead Inc.
Mountainside, NJ

04009
Cooper Industries, Inc.
Arrow Hart Div.
Hartford, CT

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, CA

04221
Midland-Ross Corp.
Midtex Div.
N. Mankato, MN

04222
AVX Corp.
AVX Ceramics Div.
Myrtle Beach, SC

04423
Telonic Berkley Inc.
Laguna Beach, CA

04713
Motorola Inc.
Semiconductor Group
Phoenix, AZ

04946
Standard Wire and Cable
Rancho Dominquez, CA

05173
General Radio
NY,NY.
Replaced by:

24655
Genrad,INC.
Concord, MA

05236
Jonathan Mfg. Co.
Fullerton, CA

05245
Corcom Inc.
Libertyville, IL

05276
ITT Pomona
Electronics Div.
Pomona, CA

05277
Westinghouse Elec. Corp.
Semiconductor Div.
Youngwood, PA

05347
Ultronix Inc
Grand Junction, CO

05397
Union Carbide Corp.
Materials Systems Div.
Cleveland. OH

05571
Sprague Electric Co.
(Now 56289)

05574
Viking Connectors Inc
Sub of Criton Corp.
Chatsworth, CA

05791
LYN-TRON
Burbank, CA

05820
EG & G Wakefield Engineering
Wakefield, MA

05839
Advance Electrical
Chicago, IL

05972
Loctite Corp.
Newington, CT

Federal Supply Codes for Manufacturers (cont)

06001
General Electric Co.
Electric Capacitor Product Section
Columbia, SC

06141
Fairchild Weston Systems Inc.
Data Systems Div.
Sarasota, FL

06192
La Deau Mfg. Co.
Glendale, CA

06229
Electrovert Inc.
Elmsford, NY

06383
Panduit Corp.
Tinley Park, IL

06473
Bunker Ramo Corp.
Amphenol NA Div.
SAMS Operation
Chatsworth, CA

06540
Mite Corp
Amatom-Electrical Div

06555
Beede Electrical Instrument
Penacook, NH

06665
Precision Monolithics
Sub of Bourns Inc.
Santa Clara, CA

06666
General Devices Co. Inc.
INpolis, IN

06739
Electron Corp.
Littleton, CO

06743
Gould Inc.
Foil Div.
Eastlake, OH

06751
Components Inc.
Semcor Div.
Phoenix, AZ

06776
Robinson Nugent Inc.
New Albany, IN

06915
Richco Plastic Co.
Chicago, IL

06961
Vernitron Corp.
Piezo Electric Div.
Bedford, OH

06980
EIMAC
(See Varian)
San Carlos, CA

07047
Ross Milton Co., The
Southampton, PA

07138
Westinghouse Electric Corp.
Industrial & Govemment Tube Div.
Horseheads, NY

07233
Benchmark Technology Inc.
City of Industry, CA

07239
Biddle Instruments
Blue Bell, PA

07256
Silicon Transistor Corp.
Sub of BBF Inc.
Chelmsford, MA

07261
Avnet Corp.
Culver City, CA

07263
Fairchild Semiconductor
North American Sales
Ridgeview, CT

07344
Bircher Co. Inc., The
Rochester, NY

07374
Optron Corp
Woodbridge, CT

07557
Campion Co. Inc.
Philadelphia, PA

07597
Bumdy Corp.
Tape/Cable Div.
Rochester, NY

07716
TRW Inc. (Can use 11502)
IRC Fixed Resistors/ Burlington
Burlington, VT

07792
Lemma Engineering Corp.
Northampton, MA

07810
Bock Corp.
Madison, WI

07910
Teledyne Semiconductor
Mtn. View, CA

07933
Raytheon Co.
Semiconductor Div.
Mountain View, CA

08FG6
Calmos Systems Inc.
Kanata, Ont. Canada

080A9
Dallas Semiconductor
Dallas, TX

08111
MF Electronics
New Rochelle, NY

08235
Industro Transistor Corp.
Long Island City, NY

08261
Spectra-Strip
An Eltra Co.
Garden Grove, CA

08445
Electri-Cord Mfg., Inc
Westfield, PA

08530
Reliance Mica Corp.
Brooklyn, NY

08718
ITT Cannon Electric
Phoenix Div.
Phoenix, AZ

08806
General Electric Co.
Minature Lamp Products
Cleveland, OH

08863
Nylomatic
Fallsington, PA

08988
Skottie Electronics Inc.
Archbald, PA

09021
Airco Inc.
Airco Electronics
Bradford, PA

09023
Cornell-Dublier Electronics
Fuquay-Varina, NC

09214
General Electric Co.
Semiconductor Products Dept.
Aubum, NY

09353
C and K Components Inc.
Newton, MA

09423
Scientific Components Inc.
Santa Barbara, CA

09922
Bumdy Corp.
Norwalk, CT

09969
Dale Electronics Inc.
Yankton, SD

09975
Burroughs Corp.
Electronics Components
Detroit, MI

1A791
LFE Electronics
Danvers, MA

1B715
(United Shoe & Nylock Corp)
-Nylock Fastener Corp.-
Paramus, NJ

10059
Barker Engineering Corp.
Kenilworth, NJ

10389
IL Tool Works Inc.
Licon Div.
Chicago, IL

11236
CTS Corp.
Resistor Products Div.
Berne, IN

11237
CTS Corp of CA
Electro Mechanical Div.
Paso Robles, CA

11295
ECM Motor Co.
Schaumburg, IL

11358
Columbia Broadcasting System
CBS Electronic Div.
Newburyport, MA

11403
Vacuum Can Co.
Best Coffee Maker Div.
Chicago, IL

11502 (can also use 35009)
TRW Inc.
TRW Resistive Products Div.
Boone, NC

11503
Keystone Columbia Inc.
Freemont, IN

11532
Teledyne Relays Teledyne Industries Inc.
Hawthorne, CA

11711
General Instrument Corp.
Rectifier Div.
Hicksville, NY

11726
Qualidyne Corp.
Santa Clara, CA

12014
Chicago Rivet & Machine Co.
Naperville, IL

12020
Ovenaire
Div. of Electronic Technologies
Charlottesville, VA

12038
Simco
(Div of Ransburg Corp)
Hatfield, PA

12040
National Semiconductor Corp.
Danbury, CT

Federal Supply Codes for Manufacturers (cont)

12060
Diodes Inc.
Northridge, CA

12136
PHC Industries Inc.
Formerly Philadelphia Handle Co.
Camden, NJ

12300
AMF Canada Ltd.
Potter-Brumfield
Guelph, Ontario, Canada

12323
Practical Automation Inc.
Shelton, CT

12327
Freeway Corp.
Cleveland, OH

12406
Elpac Electronics Inc.
Santa Ana, CA

12443
Budd Co.,The
Plastics Products Div.
Phoenixville, PA

12581
Hitachi Metals International Ltd.
Hitachi Magna-Lock Div.
Big Rapids, MO

12615
US Terminals Inc.
Cincinnati, OH

12617
Hamlin Inc.
LaKe Mills, WI

12673
Wesco Electrical
Greenfield, MA

12697
Clarostat Mfg. Co. Inc.
Dover, NH

12749
James Electronic Inc.
Chicago, IL

12856
MicroMetals Inc.
Anaheim, CA

12881
Metex Corp.
Edison, NJ

12895
Cleveland Electric Motor Co.
Cleveland, OH

12954
Microsemi Corp.
Components Group
Scottsdale, AZ

12969
Unitrode Corp.
Lexington, MA

13050
Potter Co.
Wesson, MS

13103
Thermalloy Co., Inc.
Dallas, TX

13327
Solitron Devices Inc.
Tappan, NY

13511
Bunker-Ramo Corp.
Amphenol Cadre Div.
Los Gatos, CA

13606
Sprague Electric Co.
(Use 56289)

13689
SPS Technologies Inc.
Hatfield, NJ

13764
Micro Plastics
Flippin, AZ

13919
Burr-Brown Research Corp.
Tucson, AZ

14099
Semtech Corp.
Newbury Park, CA

14140
McGray-Edison Co.
Commercial Development Div.
Manchester, NH

14189
Ortronics, Inc.
Orlando, FL

14193
Cal-R-Inc.
Santa Monica, CA

14301
Anderson Electronics
Hollidaysburg, PA

14329
Wells Electronics Inc.
South Bend, IN

14482
Watkins-Johnson Co.
Palo Alto, CA

14552
Microsemi Corp.
(Formerly Micro-Semiconductor)
Santa Ana, CA

14604
Elmwood Sensors, Inc
Pawtucket, RI

14655
Cornell-Dublier Electronics
Div. of Federal Pacific
Electric Co. Govt Cont Dept.
Newark, NJ

14704
Crydom Controls
(Division of Int Rectifier)
El Segundo, CA

14752
Electro Cube Inc.
San Gabriel, CA

14936
General Instrument Corp.
Discrete Semi Conductor Div.
Hicksville, NY

14949
Trompeter Electronics
Chatsworth, CA

15412
Amtron
Midlothian, IL

15542
Scientific Components Corp.
Mini-Circuits Laboratory Div.
Brooklyn, NY

15636
Elec-Trol Inc.
Saugus, CA

15782
Bausch & Lomb Inc.
Graphics & Control Div.
Austin, TX

15801
Fenwal Eletronics Inc.
Div. of Kidde Inc.
Framingham, MA

15818
Teledyne Inc. Co.
Teledyne Semiconductor Div.
Mountain View, CA

15849
Useco Inc.
(Now 88245)

15898
International Business
Machines Corp.
Essex Junction, VT

16068
International Diode Div.
Harrison, NJ

16162
MMI
Southfield, MI

16245
Conap Inc.
Olean, NY

16258
Space-Lok Inc.
Burbank, CA

16352
Codi Corp.
Linden, NJ

16469
MCL Inc.
LaGrange, IL

16473
Cambridge Scientific Industries
Div. of Chemed Corp.
Cambridge, MD

16733
Cablewave Systems Inc.
North Haven, CT

16742
Paramount Plastics
Fabricators Inc.
Downey, CA

16758
General Motors Corp.
Delco Electronics Div.
Kokomo, IN

17069
Circuit Structures Lab
Burbank, CA

17117
Electronic Molding Corp.
Woonsocket, RI

17338
High Pressure Eng. Co. Inc.
OK City, OK

17504
Aluminum Filter Co.
Carpinteria, CA

17545
Atlantic Semiconductors Inc.
Asbury Park, NJ

17745
Angstrohm Precision, Inc.
Hagerstown, MD

17856
Siliconix Inc.
Santa Clara, CA

18178
E G & Gvactee Inc.
St. Louis, MO

18235
KRL/Bantry Components Inc.
Manchester, NH

18310
Concord Electronics
New York, NY

18324
Signetics Corp.
Sacramento, CA

18377
Parlex Corp.
Methuen, MA

18520
Sharp Electronics Corp.
Paramus, NJ

18542
Wabash Inc.
Wabash Relay & Electronics Div.
Wabash, IN

Federal Supply Codes for Manufacturers (cont)

18565
Chomerics Inc.
Woburn, MA

18612
Vishay Intertechnology Inc.
Vishay Resistor Products Group
Malvern, PA

18632
Norton-Chemplast
Santa Monica, CA

18677
Scanbe Mfg. Co.
Div. of Zero Corp.
El Monte, CA

18736
Voltronics Corp.
East Hanover, NJ

18786
Micro-Power
Long Island City, NY

18927
GTE Products Corp.
Precision Material Products
Business Parts Div.
Titusville,PA

19080
Robinson Electronics Inc.
San Luis Obispo, CA

19112
Garry Corp.
Langhorne, PA

19315
Bendix Corp., The
Navigation & Control Group
Terboro, NJ

19451
Perine Machine Tool Corp.
Kent, WA

19482
Delta Electronics
Alexandria, VA

19613
MN Mining & Mfg. Co.
Textool Products Dept.
Electronic Product Div.
Irving, TX

19647
Caddock Electronics Inc.
Riverside, CA

19701
Mepco/Centralab Inc.
A N. American Philips Co.
Mineral Wells, TX

2B178
Wire Products
Cleveland, OH

2K262
Boyd Corporation
Portland, OR

2Y384
North American Philips Lighting Corp.
Van Wert, OH

20584
Enochs Mfg. Inc.
INpolis, IN

20891
Cosar Corp.
Dallas, TX

21317
Electronics Applications Co.
El Monte, CA

21604
Buckeye Stamping Co.
Columbus, OH

21845
Solitron Devices Inc.
Semiconductor Group
Rivera Beach, FL

21847
Aertech
Now TRW Microwave Inc.
Sunnyvale, CA

21962
Vectron Corp.
Replaced by: S.W. Electronics

22526
DuPont, EI DeNemours & Co. Inc.
DuPont Connector Systems
Advanced Products Div.
New Cumberland, PA

22626
Micro Semiconductor
(Now 14552)

22670
GM Nameplate
Seattle, WA

22767
ITT Semiconductors
Palo Alto, CA

22784
Palmer Inc.
Cleveland, OH

23050
Product Comp. Corp.
Mount Vernon, NY

23223
CTS Microelectronics
Lafayette, NY

23237
I.R.C., Inc.
Microcircuits Divison
Philadelphia, PA

23302
S.W. Electronics & Mfg. Corp.
Cherry Hill, NJ

23730
Mark Eyelet and Stamping Inc.
Wolcott, CT

23732
Tracor Applied Sciences Inc.
Rockville, MD

23880
Stanford Applied Engineering
Santa Clara, CA

23936
William J. Purdy Co.
Pamotor Div.
Burlingame, CA

24347
Penn Engineering Co.
S. El Monte, CA

24355
Analog Devices Inc.
Norwood, MA

24444
General Semiconductor
Industries, Inc.
Tempe, AZ

24546
Bradford Electronics
Bradford, PA

24618
Transcon Mfg.
Now: D.J. Associates Inc.

24655
Genrad Inc.
(Replaced General Radio 05173)
Concord, MA

24759
Lenox-Fugle Electronics Inc.
South Plainfield, NJ

24796
AMF Inc.
Potter & Brumfield Div.
San Juan Capistrano, CA

24931
Specialty Connector Co.
Greenwood, IN

24995
ECS
Grants Pass, OR

25088
Siemen Corp.
Isilen, NJ

25099
Cascade Gasket
Kent, WA

25403
Amperex Electronic Corp.
Semiconductor & Micro-Circuit Div.
Slatersville, RI

25435
Moldtronics, Inc
Downers Grove, IL

25706
Dabum Electronic & Cable Corp.
Norwood, NJ

26402
Lumex,Inc.
Bayshore, NY

26629
Frequency Sources Inc.
Sources Div.
Chelmsford, MA

26806
American Zettler Inc.
Irvine, CA

27014
National Semiconductor Corp.
Santa Clara, CA

27167
Corning Glass Works Corning
Electronics
Wilmington, NC

27264
Molex Inc.
Lisle, IL

27440
Industrial Screw Products
Los Angeles, CA

27494
Staffall, Inc.
Providence, RI

27745
Associated Spring Barnes Group Inc.
Syracuse, NY

27918
Component Parts Corp.
Bellmore, NY

27956
Relcom (Now 14482)

28175
Alpha Metals
Chicago, IL

28198
Positronic Industries
Springfield, MO

28213
MN Mining & Mfg. Co.
Consumer Products Div.
3M Center
Saint Paul, MN

28309
Kaiser
Minette,AL.

28425
Serv-O-Link
Euless, TX

28478
Deltrol Corporation
Deltrol Controls Div.
Milwaukee, WI

28480
Hewlett Packard Co.
Corporate HQ
Palo Alto, CA

Federal Supply Codes for Manufacturers (cont)

28484
Emerson Electric Co.
Gearmaster Div.
McHenry, IL

28520
Heyco Molded Products
Kenilworth, NJ

28932
Lumax Industrials, Inc
Altoona, PA

29083
Monsanto Co.
Santa Clara, CA

29604
Stackpole Components Co.
Raleith, NC

29907
Omega Engineering Inc.
Stamford, CT

3D536
Aimsco Inc.
Seattle, WA

30035
Jolo Industries Inc.
Garden Grove, CA

30045
Solid Power Corp.
Farmingdale, NY

30146
Symbex Corp.
Painesville, OH

30148
AB Enterprise Inc.
Ahoskie, NC

30161
Aavid Engineering Inc.
Laconia, NH

30315
Itron Corp.
San Diego, CA

30323
IL Tool Works Inc.
Chicago, IL

30800
General Instrument Corp.
Capacitor Div.
Hicksville, NY

30838
Fastec
Chicago,ILL

31019
Solid State Scientific Inc.
Willow Grove, PA

31091
Alpha Industries Inc.
Microelectronics Div.
Hatfield, PA

31323
Metro Supply Company
Sacramento, CA

31433
Kemet Electonics Corp.
Simpsonville, NC

31448
Army Safeguard Logistics Command
Huntsville, AL

31471
Gould Inc
Semiconductor Div
Santa Clara, CA

31522
Metal Masters Inc.
Baldwin, MS

31746
Cannon Electric
Woodbury, TN

31827
Budwig
Ramona, CA

31918
ITT-Schadow
Eden Prairie, MN

32293
Intersil
Cupertino, CA

32539
Mura Corp.
Westbury, Long Island, N.Y.

32559
Bivar
Santa Ana, CA

32719
Siltronics
Santa Ana, CA

32767
Griffith Plastics Corp.
Burlingame, CA

32879
Advanced Mechanical Components
Northridge, CA

32897
Murata Erie North America Inc.
Carlisle Operations
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Div.
Riverside, CA

33025
M/A ComOmni Spectra, Inc. (Replacing Omni Spectra)
Microwave Subsystems Div.
Tempe, AZ

33096
CO Crystal Corp.
Loveland, CO

33173
General Electric Co.
Owensboro, KY

33246
Epoxy Technology Inc.
Billerica, MA

33292
Pioneer Sterilized Wiping Cloth Co.
Portland, OR

33297
NEC Electronics USA Inc.
Electronic Arrays Inc. Div.
Mountain View, CA

33919
Nortek Inc.
Cranston, RI

34114
Oak Industries
Rancho Bernardo, CA

34263
CTS Electronics Corp.
Brownsville,TX

34333
Silicon General Inc.
Garden Grove, CA

34335
Advanced Micro Devices (AMD)
Sunnyvale, CA

34359
MN Mining & Mfg. Co.
Commercial Office Supply Div.
Saint Paul, MN

34371
Harris Corp.
Harris Semiconductor
Products Group
Melbourne, FL

34576
Rockwell International Corp.
Newport Beach, CA

34641
Instrument Specialties
Euless, TX

34649
Intel Corp.
Santa Clara, CA

34802
Electromotive Inc.
Kenilworth, NJ

34848
Hartwell Special Products
Placentia, CA

35009
Renfrew Electric Co. Ltd.
IRC Div.
Toronto, Ontario, Canada

35986
Amrad
Melrose Park, IL

36665
Mitel Corp.
Kanata, Ontario, Canada

36701
Van Waters & Rogers
Valley Field, Quebec, Canada

37942
Mallory Capacitor Corp.
Sub of Emhart Industries
INpolis, IN

39003
Maxim Industries
Middleboro, MA

4F434
Plastic Sales
Los Angeles, CA

40402
Roderstein Electronics Inc.
Statesville, NC

42498
National Radio
Melrose, MA

43543
Nytronics Inc.(Now 53342)

43744
Panasonic Industrial Co.
San Antonio, TX

43791
Datron Systems
Wilkes Barre, PA

44655
Ohmite Mfg. Co.
Skokie, IL

47001
Lumberg Inc.
Richmond, VA

47379
ISOCOM
Campbell, CA

49569
IDT (International Development & Trade)
Dallas, TX

49671
RCA Corp.
New York, NY

49956
Raytheon Company
Executive Offices
Lexington, MA

5D590
Mostek Corp.
Replaced by: SGS Thompson Microelectronics

5F520
Panel Components Corp.
Santa Rosa, CA

5P575
Nobel Electronics
Suffern, NY

5W664
NDK
Div. of Nihon Dempa Kogyo LTD
Lynchburg, VA

Federal Supply Codes for Manufacturers (cont)

5U802
Dennison Mfg. Co.
Framingham, MA

50088
SGS - Thomson Microelectronics Inc.
Carrollton, TX

50120
Eagle-Picher Industries Inc.
Electronics Div.
CO Springs, CO

50157
Midwest Components Inc.
Muskegon, MS

50356
Teac Corp. of America
Industrial Products Div
Montebello, CA

50364
MMI, Inc.(Monolithic Memories Inc)
Military Products Div.
Santa Clara, CA

50472
Metal Masters, Inc.
City of Industry, CA

50541
Hypertronics Corp.
Hudson, MA

50558
Electronic Concepts, Inc.
Eatontown, NJ

50579
Litronix Inc.
Cupertino, CA

50891
Semiconductor Technology
Stuart, FL

50934
Tran-Tec Corp
Columbus, NE

51167
Aries Electronics Inc.
Frenchtown, NJ

51284
Mos Technology
Norristown, PA

51249
Heyman Mfg. Co.
Cleveland, OH

51372
Verbatim Corp.
Sunnyvale, CA

51398
MUPAC Corp.
Brockton, MA

51406
Murata Erie, No. America Inc.
(Also see 72982)
Marietta, GA

51499
Amtron Corp.
Boston, MA

51506
Accurate Screw Machine Co.
(ASMCO) Nutley, NJ

51605
CODI Semiconductor Inc.
Kenilworth, NJ

51642
Centre Engineering Inc.
State College, PA

51705
ICO/Rally
Palo alto, CA

51791
Statek Corp.
Orange, CA

51984
NEC America Inc.
Falls Church, VA

52063
Exar Integrated Systems
Sunnyvale, CA

52072
Circuit Assembly Corp.
Irvine, CA

52152
MN Mining & Mfg.
Saint Paul, MN

52333
API Electronics
Haugpauge,Long Island,NY

52361
Communication Systems
Piscataway, NJ

52500
Amphenol, RF Operations
Burlington, MA

52525
Space-Lok Inc.
Lerco Div.
Burbank, CA

52531
Hitachi Magnetics
Edmore, MO

52745
Timco
Los Angeles, CA

52763
Stettner-Electronics Inc.
Chattanooga, TN

52769
Sprague-Goodman Electronics Inc.
Garden City Park, NY

52771
Moniterm Corp.
Amatrom Div.
Santa Clara, CA

52840
Western Digital Corp.
Costa Mesa, CA

53021
Sangamo Weston Inc.
(See 06141)

53036
Textool Co.
Houston, TX

53184
Xciton Corp.
Lathan, NY

53217
Technical Wire Products Inc.
Santa Barbara, CA

53342
Opt Industries Inc.
Phillipsburg, NJ

53673
Thompson CSF Components Corp.
(Semiconductor Div)
Conaga Park, CA

53718
Airmold/W. R. Grese & Co.
Roanoke Rapids, NC

53848
Standard Microsystems
Hauppauge, NY

53894
AHAM Inc.
RanchoCA, CA

53944
Glow-Lite
Pauls Valley, OK

54178
Plasmetex Industries Inc.
San Marcos, CA

54294
Shallcross Inc.
Smithfield, NC

54453
Sullins Electronic Corp.
San Marcos, CA

54473
Matsushita Electric Corp.
(Panasonic)
Secaucus, NJ

54492
Cinch Clamp Co., Inc.
Santa Rosa, CA

54583
TDK
Garden City, NY

54590
RCA Corp
Distribution & Special Products
Cherry Hill, NY

54869
Piher International Corp.
Arlington Heights, IL

54937
DeYoung Mfg.
Bellevue, WA

54590
RCA Corp.
Electronic Components Div.
Cherry Hill, NJ

55026
American Gage & Machine Co.
Simpson Electric Co. Div.
Elgin, IL

55112
Plessey Capacitors Inc.
(Now 60935)

55261
LSI Computer Systems Inc.
Melville, NY

55285
Bercquist Co.
Minneapolis, MN

55322
Samtech Inc.
New Albany, IN

55408
STI-CO Industries Co
Buffalo, NY

55464
Central Semiconductor Corp.
Hauppauge, NY

55557
Microwave Diode Corp.
W.Stewarstown, NH

55566
R A F Electronic Hardware Inc.
Seymour, CT

55576
Synertek
Santa Clara, CA

55680
Nichicon/America/Corp.
Schaumburg, IL

55943
D J Associates, Inc
(Replaced Transcon Mfg.-24618)
Fort Smith, AZ

56282
Utek Systems Inc.
Olathe, KS

56289
Sprague Electric Co.
North Adams, MA

56365
Square D Co.
Corporate Offices
Palatine, IL

56375
WESCORP
Div. Dal Industries Inc
Mountain View, CA

Federal Supply Codes for Manufacturers (cont)

56481
Shugart Associates
Sub of Xerox Corp.
Sunnyvale, CA

56637
RCD Components Inc.
Manchester, NH

56708
Zilog Inc.
Campbell, CA

56856
Vamistor Corp. of TN
Sevierville, TN

56880
Magnetics Inc.
Baltimore, MD

57026
Endicott Coil Co. Inc.
Binghamton, NY

57053
Gates Energy Products
Denver, CO

57170
Cambridge Thermionic
Cambridge, MA
Replaced by:
71279
Interconnection Products Inc.

57668
R-ohm Corp
Irvine, CA

57962
SGS - Thomson Microelectronics Inc
Montgomeryville, PA

58014
Hitachi Magnalock Corp.
(Now 12581)

58104
Simco
Atlanta, GA

58364
BYCAP Inc.
Chicago, IL

58451
Precision Lamp
Cotat, CA

58474
Superior Electric Co.
Bristol, CT

58614
Communications Instruments Inc.
Fairview, NC

59124
KOA-Speer Electronics Inc.
Bradford, PA

59422
Holmberg Electronics
Irvine, CA

59610
Souriau Inc
Valencia, CA

59635
HV Component Associates
Howell, NJ

59640
Supertex Inc.
Sunnyvale, CA

59660
Tusonix Inc.
Tucson, AZ

59730
Thomas and Betts Corp.
IA City, IA

59831
Semtronics Corp.
Watchung, NJ

6II053:
American Components Inc.
an Insilco Co. RPC Div.
Hayesville, NC

6L611
Allen, Robert G. Inc.
Van Nuys, CA

6U850
Burgess Switch Co., Inc
Northbrook, IL

6U095
AMD Enterprises, Inc.
Roswell, GA

6X403
SGS/ATES Semiconductor Corp.
INpolis, IN

6Y440
Micron Technology Inc.
Boise, ID

60046
Power Dynamics Inc
West Orange, NJ

60197
Precicontact Inc.
Langhorne, PA

60386
Squires Electronics Inc
Cornelius, OR

60395
Xicor Inc.
Milpitas, CA

60399
Torin Engineered Blowers
Div. of Clevepak Corp.
Torrington, CT

60496
Micrel Inc.
Sunnyvale, CA

60705
Cera-Mite Corp.
(formerly Sprague)
Grafton, WI

60911
Inmos Corp.
CO Springs, CO

60935
Westlake Capacitor Inc.
Tantalum Div.
Greencastle, IN

60958
ACIC
Intercomp Wire & Cable Div.
Hayesville, NC

61271
Fujitsu Microelectronics Inc
San Jose, CA

61394
SEEQ Technology Inc.
San Jose, CA

61429
Fox Electronics
Cape Coral, FL

61529
Aromat Corp.
New Providence, NJ

61752
IR-ONICS Inc
Warwick, RI

61772
Integrated Device Technology
Santa Clara, CA

61802
Toshiba
Houston, TX

61857
SAN-O Industrial Corp.
Bohemia, Long Island, NY

61935
Schurter Inc.
Petaluma, CA

62351
Apple Rubber
Lancaster, NY

62643
United Chemicon
Rosemont, IL

62712
Seiko Instruments
Torrance, CA

62793
Lear Siegler Inc.
Energy Products Div.
Santa Ana, CA

63743
Ward Leonard Electric Co.Inc.
Mount Vernon, NY

64154
Lamb Industries
Portland, OR

64155
Linear Technology
Milpitas, CA

64537
KDI Electronics
Whippany, NJ

64782
Precision Control Mfg. Inc.
Bellevue, WA

64834
West M G Co.
San Francisco, CA

64961
Electronic Hardware LTD
North Hollywood, CA

65092
Sangamo Weston Inc.
Weston Instruments Div.
Newark, NJ

65786
Cypress Semi
San Jose, CA

65940
Rohm Corp & Whatney
Irvine, CA

65964
Evox Inc.
Bannockburn, IL

66150
Entron Inc.
Winslow Teltronics Div.
Glendale, NY

66302
VLSI Technology Inc.
San Jose, CA

66419
Exel
San Jose, CA

66450
Dyna-Tech Electronics, Inc
Walled Lake, MI

66608
Bering Industries
Freemont, CA

66891
BKC International Electronics
Lawrence, MA

66958
SGS Semiconductor Corp.
Phoenix, AZ

66967
Powerex Inc
Auburn, NY

67183
Altera
Santa Clara, CA

68919
WIMA
% Harry Levinson Co.
Seattle, WA

Federal Supply Codes for Manufacturers (cont)

7F361
Richmond-Division of Dixico
% Zellerbach Paper Co.
Seattle, WA

7F844
Moore Business Forms, Inc
Seattle, WA

7G902
Textron Inc.
Camcar Div.
Rockford, IL

7J395
Universal Plastics
Welshpool, WA

7J696
AMD Plastics
East Lake, OH

7K354
Omni Spectra Inc
Los Altos, CA

7Z884
ALPS
Seattle, WA

7X634
Duracell USA
Div. of Dart & Kraft Inc.
Valdese, NC

70290
Almetal Universal Joint Co.
Cleveland, OH

70485
Atlantic India Rubber Works Inc.
Chicago, IL

70563
Amperite Company
Union City, NJ

70903
Cooper-Belden Corp.
Geneva, IL

71002
Bimbach Co. Inc.
Farmingdale, NY

71034
Bliley Electric Co.
Erie, PA

71183
Westinghouse Electric Corp.
Bryant Div.
Bridgeport, CT

71279
Interconnection Products Inc.
Formerly Midland-Ross Cambion Div.
Santa Ana, CA

71400
Bussman Manufacturing
Div. McGraw-Edison Co.
St. Louis, MO

71450
CTS Corp.
Elkhart, IN

71468
ITT Cannon Div. of ITT
Fountain Valley, CA

71482
General Instrument Corp.
Clare Div.
Chicago, IL

71590
Mepco/Centralab
A North American Philips Co.
Fort Dodge, IA

71707
Coto Corp.
Providence, RI

71744
General Instrument Corp.
Lamp Div/Worldwide
Chicago, IL

71785
TRW Inc.
Cinch Connector Div.
Elk Grove Village, IL

71984
Dow Corning Corp.
Midland, MI

72005
AMAX Specialty Metals Corp.
Newark, NJ

72136
Electro Motive Mfg. Corp.
Florence, NC

72228
AMCA International Corp.
Continental Screw Div.
New Bedford, MA

72259
Nytronics Inc.
New York, NY

72619
Amperex Electronic Corp.
Dialight Div.
Brooklyn, NY

72653
G C Electronics Co.
Div. of Hydrometals Inc.
Rockford, IL

72794
Dzus Fastner Co. Inc.
West Islip, NY

72928
Gulton Industries Inc.
Gudeman Div.
Chicago, IL

72962
Elastic Stop Nut
Div. of Harrard Industries
Union, NJ

72982
Erie Specialty Products, Inc
Formerly: Murata Erie
Erie, PA

73138
Beckman Industrial corp.
Helipot Div.
Fullerton, CA

73168
Fenwal Inc.
Ashland, MA

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrance, CA

73445
Amperex Electronic Corp.
Hicksville, NY

73559
Carlingswitch Inc.
Hartford, CT

73586
Circle F Industries
Trenton, NJ

73734
Federal Screw Products Inc.
Chicago, IL

73743
Fischer Special Mfg. Co.
Cold Spring, KY

73893
Microdot
Mt. Clemens, MS

73899
JFD Electronic Components
Div. of Murata Erie
Oceanside, NY

73905
FL Industries Inc.
San Jose, CA

73949
Guardian Electric Mfg. Co.
Chicago, IL

74199
Quam Nichols Co.
Chicago, IL

74217
Radio Switch Co.
Marlboro, NJ

74306
Piezo Crystal Co.
Div. of PPA Industries Inc.
Carlisle, PA

74445
Holo-Krome Co.
Elmwood, CT

74542
Hoyt Elect.Instr. Works Inc.
Penacook, NH

74840
IL Capacitor Inc.
Lincolnwood, IL

74970
Johnson EF Co.
Waseca, MN

75042
TRW Inc.
IRC Fixed Resistors
Philadelphia, PA

75297
Kester Solder Div.
Litton Systems, Inc
Des Plaines, IL

75376
Kurz-Kasch Inc.
Dayton, OH

75378
CTS Knights Inc.
Sandwich, IL

75382
Kulka Electric Corp.
(Now 83330)
Mount Vernon, NY

75569
Performance Semiconductor Corp.
Sunnyvale, CA

75915
Littelfuse Tracor
(Formerly: Tracor-Littelfuse)
Des Plaines, IL

76854
Oak Switch Systems Inc.
Crystal Lake, IL

77122
TRW Assemblies & Fasteners Group
Fastener Div.
Moutainside, NJ

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, IN

77542
Ray-O-Vac Corp
Madison, WI

77638
General Instrument Corp.
Rectifier Div.
Brooklyn, NY

77900
Shakeproof Lock Washer Co.
(Now 78189)

77969
Rubbercraft Corp. of CA Ltd.
Torrance, CA

78189
IL Tool Works Inc.
Shakeproof Div.
Elgin, IL

78277
Sigma Instruments Inc.
South Braintree, MA

78290
Struthers Dunn Inc.
Pitman, NJ

78553
Eaton Corp.
Engineered Fastener Div.
Cleveland, OH

Federal Supply Codes for Manufacturers (cont)

78592
Stoeger Industries
South Hackensack, NJ

79497
Western Rubber Co.
Goshen, IN

79727
C - W Industries
Southampton, PA

79963
Zierick Mfg. Corp.
Mount Kisco, NY

8C798
Ken-Tronics, Inc.
Milan, IL

8D528
Baumgartens
Atlanta, GA

8F330
Eaton Corp.
Cutler Hammer Product Sales Office
Mountain View, CA

8T100
Tellabs Inc.
Naperville, IL

80009
Tektronix
Beaverton, OR

80031
Mepco/Electra Inc.
Morristown, NJ

80032
Ford Aerospace &
Communications Corp.
Western Development
Laboratories Div.
Palo Alto, CA

80145
LFE Corp.
Process Control Div.
Clinton, OH

80183
Sprague Products
(Now 56289)

80294
Bourns Instruments Inc.
Riverside, CA

80583
Hammerlund Mfg. Co. Inc.
Paramus, NJ

80640
Computer Products Inc.
Stevens-Arnold Div.
South Boston, MA

81073
Grayhill Inc.
La Grange, IL

81312
Litton Systems Inc.
Winchester Electronics Div.
Watertown, CT

81439
Therm-O-Disc Inc.
Mansfield, OH

81483
International Rectifier Corp.
Los Angeles, CA

81590
Korry Electronics Inc.
Seattle, WA

81741
Chicago Lock Co.
Chicago, IL

82227
Airpax Corp.
Cheshire Div.
Cheshire, CT

82240
Simmons Fastner Corp.
Albany, NY

82305
Palmer Electronics Corp.
South Gate, CA

82389
Switchcraft Inc.
Sub of Raytheon Co.
Chicago, IL

82415
Airpax Corp
Frederick Div.
Frederick, MD

82872
Roanwell Corp.
New York, NY

82877
Rotron Inc.
Custom Div.
Woodstock, NY

82879
ITT
Royal Electric Div.
Pawtucket, RI

83003
Varo Inc.
Garland, TX

83014
Hartwell Corp.
Placentia, CA

83055
Signalite Fuse Co.
(Now 71744)

83058
TRW Assemblies & Fasteners Group
Fasteners Div.
Cambridge, MA

83259
Parker-Hannifin Corp.
O-Seal Div.
Culver City, CA

83298
Bendix Corp.
Electric & Fluid Power Div.
Eatonville, NJ

83315
Hubbell Corp.
Mundelein, IL

83330
Kulka Smith Inc.
A North American Philips Co.
Manasquan, NJ

83478
Rubbercraft Corp. of America
West Haven, CT

83553
Associated Spring Barnes Group
Gardena, CA

83740
Union Carbide Corp.
Battery Products Div.
Danbury, CT

84171
Arco Electronics
Commack, NY

84411
American Shizuki
TRW Capacitors Div.
Ogallala, NE

84613
FIC Corp.
Rockville, MD

84682
Essex Group Inc.
Peabody, MA

84830
Lee Spring Co. Inc
Brooklyn, NY

85367
Bearing Distributing Co.
San Fransisco, CA

85372
Bearing Sales Co.
Los Angeles, CA

85480
W. H. Brady Co.
Industrial Product
Milwaukee, WI

85840
Brady WH Co
Industrial Products Div
Milwaukee, WI

85932
Electro Film Inc.
Valencia, CA

86577
Precision Metal Products Co.
Peabody, MA

86684
Radio Corp. of America
(Now 54590)

86928
Seastrom Mfg. Co. Inc.
Glendale, CA

87034
Illuminated Products Inc.
(Now 76854)

87516
Standard Crystal
KS City, KS

88044
Aeronautical Standards Group
Dept. of Navy & Air Force

88219
GNB Inc.
Industrial Battery Div.
Langhorne, PA

88245
Winchester Electronics
Litton Systems-Useco Div.
Van Nuys, CA

88486
Triangle PWC Inc.
Jewitt City, CT

88690
Essex Group Inc.
Wire Assembly Div.
Dearborn, MI

88786
Atlantic India Rubber Co.
Goshen, IN

88978
Philips (Now Fluke)
Mahwah, NJ

89020
Amerace Corp.
Buchanan Crimptool Products Div.
Union, NJ

89265
Potter-Brumfield
(See 77342)

89462
Waldes Truarc, Inc.
Long Island, NY

89536
John Fluke Mfg. Co., Inc.
Everett, WA

89597
Fredericks Co.
Huntingdon Valley, PA

89709
Bunker Ramo-Eltra Corp.
Amphenol Div.
Broadview, IL

89730
General Electric
Lamp Div.
Newark, NJ

9R216
Data Composition Svc, Inc
Laurel, MD

9S171
Port Plastics
Tukwila, WA

Federal Supply Codes for Manufacturers (cont)

9W423
Amatom
El Mont, CA

90201
Mallory Capacitor Co.
Sub of Emhart Industries Inc.
Indianapolis, IN

90215
Best Stamp & Mfg. Co.
KS City, MO

90303
Duracell Inc.
Technical Sales & Marketing
Bethel, CT

91094
Essex Group Inc.
Suflex/IWP Div.
Newmarket, NH

91247
IL Transformer Co.
Chicago, IL

91293
Johanson Mfg. Co.
Boonton, NJ

91462
Alpha Industries Inc.
Logansport, IN

91502
Associated Machine
Santa Clara, CA

91506
Augat Alcoswitch
N. Andover, MA

91507
Froeliger Machine Tool Co.
Stockton, CA

91637
Dale Electronics Inc.
Columbus, NE

91662
Elco Corp.
A Gulf Westem Mfg. Co.
Connector Div.
Huntingdon, PA

91737
ITT Cannon/Gremar
(Now 08718)

91802
Industrial Devices Inc.
Edgewater, NJ

91833
Keystone Electronics Corp.
NY, NY

91836
King's Electronics Co. Inc.
Tuckahoe, NY

91929
Honeywell Inc.
Micro Switch Div.
Freeport, IL

91934
Miller Electric Co.
Woonsocket, RI

91967
National Tel-Tronics
Div. of electro Audio Dynamics Inc
Meadville, PA

91984
Maida Development Co.
Hampton, VA

91985
Norwalk Valve Co.
S. Norwalk, CT

92218
Wakefield Corp., The
Wakefield, ME

92527
VTC Inc.
Bloomington, MN

92607
Tensolite Co.
Div. of Carlisle Corp.
Buchanan, NY

92914
Alpha Wire Corp.
Elizabeth, NJ

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, MA

94144
Raytheon Co.
Microwave & Power Tube Div.
Quincy, MA

94222
Southco Inc.
Concordville, PA

94988
Wagner Electric Corp.
Sub of Mcgraw-Edison Co.
Whippany, NJ

95146
Alco Electronic Products Inc.
Switch Div.
North Andover, MA

95263
Leecraft Mfg. Co.
Long Island City, NY

95275
Vitramon Inc.
Bridgeport, CT

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, OH

95348
Gordo's Corp.
Bloomfield, NJ

95354
Methode Mfg. Corp.
Rolling Meadows, IL

95573
Campion Laboratories Inc.
Detroit, MI

95712
Bendix Corp.
Electrical Comp. Div.
Franklin, IN

95987
Weckesser Co. Inc.
(Now 85480)

96733
SFE Technologies
San Fernando, CA

96853
Gulton Industries Inc.
Measurement & Controls Div.
Manchester, NH

96881
Thomson Industries Inc.
Port WA, NY

97464
Industrial Retainer Ring
Irvington, NJ

97525
EECO Inc.
Santa Ana, CA

97540
Whitehall Electronics Corp.
Master Mobile Mounts Div.
Fort Meyers, FL

97913
Industrial Electronic
Hardware Corp.
NY, NY

97945
Pennwalt Corp.
SS White Industrial Products
Piscataway, NJ

97966
CBS
Electronic Div.
Danvers, MA

98094
Machlett Laboratories Inc.
Santa Barbara. CA

98159
Rubber-Teck Inc.
Gardena, CA

98278
Malco A Microdot Co.
South Pasadena, CA

98291
Sealectro Corp.
BICC Electronics
Trumbill, CT

98372
Royal Industries Inc.
(Now 62793)

98388
Lear Siegler Inc.
Accurate Products Div.
San Deigo, CA

98978
IERC
(International Electronic Research Corp.)
Burbank, CA

99120
Plastic Capacitors Inc.
Chicago, IL

99217
Bell Industries Inc.
Elect. Distributor Div.
Sunnyvale, CA

99378
ATLEE of DE Inc.
N. Andover, MA

99392
Mepco/Electra Inc.
Roxboro Div.
Roxboro, NC

99515
Electron Products Inc.
Div. of American Capacitors
Duarte, CA

99779
Bunker Ramo- Eltra Corp.
Bames Div.
Lansdown, PA

99800
American Precision Industries
Delevan Div.
East Aurora, NY

99942
Mepco/Centralab
A North American Philips Co.
Milwaukee, WI

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Everett, WA 98203
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Buenos Aires
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Casilla 16228
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177 78 Tavros
10210 Athens
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Bangalore 560 080
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Field Service Center
Emerald Complex 1-7-264
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Secunderabad 500 003
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Hindtron Services Pvt. Ltd.
15 Community Centre
Panchshila Park
New Delhi 110 017
Tel: 011-6433675

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Tel: (021) 8195365

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Seoul 150
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46700 Petaling Jaya
Selangor
Tel: 60 3 774-3422

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Mexel Servicios en Computacion
Instrumentacion y Perifericos
Blvd. Adolfo Lopez Mateos No. 163
Col. Mixcoac
Mexico D.F.
Tel: 52-5-563-5411

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Philips Nederland
Test & Meetapparaten Div.
Postbus 115
5000 AC Tilburg
Tel: 31-13-352445

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I.I. Chundrigar Road
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Greenhills, P.O. Box 610
San Juan, Metro-Manila Zip 3113
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Bangkok 10240
Tel: 66 2 374-2516, 374-1632

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Istanbul
Tel: 90 1 1435891

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Casilla de Correo 1400
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Appendix 7A
Manual Status Information

INTRODUCTION

To identify the configuation of the pcb's used in your instrument, refer to the revision letter (marked in ink) on the component side of each pcb assembly. Table 7A-1 defines the assembly revision levels documented in this manual with an X.

NEWER INSTRUMENTS

As changes and improvements are made to the instrument, they are identified by incrementing the revision letter marked on the affected pcb assembly. These changes are documented on a supplemental change/errata sheet which, when applicable, is inserted at the front of the manual.

Table 7A-1. Manual Status Information

Ref Or Option No.	Assembly Name	Fluke Part No.	PCB revision level documented in this manual.																					
			—	A	B	C	D	E	F	G	H	J	K	L	M	N	P								
A1	Main PCB Assembly	469395	●	●	●	●	+	+	+	+	+	+	+	X											
A2	Display PCB Assembly	464479	●	●	●	+	X																		
A3	Thermocouple PCB Assembly	464461	●	●	●	●	+	+	+	+	+	X													
-002	Output PCB Assembly	466144	●	●	●	●	+	+	+	+	+	+	+	+	X										
-004	IEEE-488 Interface PCB Assembly	778486	●	+	X																				
-006	Limits PCB Assembly	466185	●	●	●	●	●	X																	

X = PCB revision level documented in this manual.
● = These revision letters were never used in the instrument.
— = No revision letter on the PCB.
+ = Revision not documented in this manual.

Section 7B
Thermocouple Reference Tables

Table 7B-1. Thermocouple Reference Tables

Temperature in °C. Reference Junction at 0°C

°C	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
0	0.000	−0.000	−0.000	−0.001	−0.001	−0.001	−0.001	−0.001	−0.002	−0.002	−0.002
10	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002	−0.003	−0.003	−0.003
20	−0.003	−0.003	−0.003	−0.003	−0.003	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002
30	−0.002	−0.002	−0.002	−0.002	−0.002	−0.001	−0.001	−0.001	−0.001	−0.001	−0.000
40	−0.000	−0.000	−0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.002	0.002
50	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.006	0.006
60	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.011	0.011
70	0.011	0.012	0.012	0.013	0.014	0.014	0.015	0.015	0.016	0.017	0.017
80	0.017	0.018	0.019	0.020	0.020	0.021	0.022	0.022	0.023	0.024	0.025
90	0.025	0.026	0.026	0.027	0.028	0.029	0.030	0.031	0.031	0.032	0.033

Temperature in °F. Reference Junction at 32°F

F	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
0	0.006	0.006	0.006	0.006	0.005	0.005	0.005	0.005	0.004	0.004	0.004
10	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002
20	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
30	0.000	0.000	0.000	−0.000	−0.000	−0.000	−0.001	−0.001	−0.001	−0.001	−0.001
40	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.002	−0.002	−0.002	−0.002	−0.002
50	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002
60	−0.002	−0.002	−0.002	−0.003	−0.003	−0.003	−0.003	−0.003	−0.003	−0.003	−0.003
70	−0.003	−0.003	−0.003	−0.003	−0.003	−0.003	−0.003	−0.002	−0.002	−0.002	−0.002
80	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002	−0.002
90	−0.002	−0.002	−0.002	−0.002	−0.002	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001
100	−0.001	−0.001	−0.001	−0.001	−0.000	−0.000	−0.000	−0.000	0.000	0.000	0.000
110	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002
120	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004	0.004
130	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006
140	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.009	0.009

TYPE

B

Platinum -6% Rhodium
vs
Platinum -30% Rhodium

Table 7B-1. Thermocouple Reference Tables (cont)

Temperature in °F. Reference Junction at 32°F

°F	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS									
0°	−.234	−.227	−.220	−.213	−.206	−.198	−.191	−.184	−.177	−.169
10°	−.162	−.155	−.148	−.140	−.133	−.126	−.118	−.111	−.104	−.096
20°	−.089	−.082	−.074	−.067	−.060	−.052	−.045	−.037	−.030	−.023
30°	−.015	−.008	.000	.007	.014	.022	.029	.037	.044	.052
40°	.059	.067	.074	.082	.089	.097	.104	.112	.120	.127
50°	.135	.142	.150	.157	.165	.173	.180	.188	.196	.203
60°	.211	.218	.226	.234	.241	.249	.257	.264	.272	.280
70°	.288	.295	.303	.311	.319	.326	.334	.342	.350	.357
80°	.365	.373	.381	.389	.396	.404	.412	.420	.428	.436
90°	.443	.451	.459	.467	.475	.483	.491	.499	.506	.514

*Not an ANSI Standard

TYPE C*

Tungsten -5% Rhenium vs Tungsten -26% Rhenium

Temperature in °C. Reference Junction at 0°C

°C	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
−40	−2.254	−2.308	−2.362	−2.416	−2.469	−2.522	−2.575	−2.628	−2.681	−2.734	−2.787
−30	−1.709	−1.764	−1.819	−1.874	−1.929	−1.983	−2.038	−2.092	−2.146	−2.200	−2.254
−20	−1.151	−1.208	−1.264	−1.320	−1.376	−1.432	−1.487	−1.543	−1.599	−1.654	−1.709
−10	−0.581	−0.639	−0.696	−0.754	−0.811	−0.868	−0.925	−0.982	−1.038	−1.095	−1.151
0	0.000	−0.059	−0.117	−0.176	−0.234	−0.292	−0.350	−0.408	−0.466	−0.524	−0.581
0	0.000	0.059	0.118	0.176	0.235	0.295	0.354	0.413	0.472	0.532	0.591
10	0.591	0.651	0.711	0.770	0.830	0.890	0.950	1.011	1.071	1.131	1.192
20	1.192	1.252	1.313	1.373	1.434	1.495	1.556	1.617	1.678	1.739	1.801
30	1.801	1.862	1.924	1.985	2.047	2.109	2.171	2.233	2.295	2.357	2.419
40	2.419	2.482	2.544	2.607	2.669	2.732	2.795	2.858	2.921	2.984	3.047
50	3.047	3.110	3.173	3.237	3.300	3.364	3.428	3.491	3.555	3.619	3.683
60	3.683	3.748	3.812	3.876	3.941	4.005	4.070	4.134	4.199	4.264	4.329
70	4.329	4.394	4.459	4.524	4.590	4.655	4.720	4.786	4.852	4.917	4.983
80	4.983	5.049	5.115	5.181	5.247	5.314	5.380	5.446	5.513	5.579	5.646
90	5.646	5.713	5.780	5.846	5.913	5.981	6.048	6.115	6.182	6.250	6.317

TYPE E

Nickel - Chromium vs Copper - Nickel

Table 7B-1. Thermocouple Reference Tables (cont)

Temperature in °F, Reference Junction at 32°F

°F	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
0	−1.026	−0.994	−0.963	−0.931	−0.900	−0.868	−0.836	−0.805	−0.773	−0.741	−0.709
10	−0.709	−0.677	−0.645	−0.613	−0.581	−0.549	−0.517	−0.485	−0.453	−0.421	−0.389
20	−0.389	−0.357	−0.324	−0.292	−0.260	−0.227	−0.195	−0.163	−0.130	−0.098	−0.065
30	−0.065	−0.033	0.000	0.033	0.065	0.098	0.131	0.163	0.196	0.229	0.262
40	0.262	0.295	0.327	0.360	0.393	0.426	0.459	0.492	0.525	0.558	0.591
50	0.591	0.624	0.658	0.691	0.724	0.757	0.790	0.824	0.857	0.890	0.924
60	0.924	0.957	0.990	1.024	1.057	1.091	1.124	1.158	1.192	1.225	1.259
70	1.259	1.292	1.326	1.360	1.394	1.427	1.461	1.495	1.529	1.563	1.597
80	1.597	1.631	1.665	1.699	1.733	1.767	1.801	1.835	1.669	1.903	1.937
90	1.937	1.972	2.006	2.040	2.075	2.109	2.143	2.178	2.212	2.247	2.281
100	2.281	2.316	2.350	2.385	2.419	2.454	2.489	2.523	2.558	2.593	2.627
110	2.627	2.662	2.697	2.732	2.767	2.802	2.837	2.872	2.907	2.942	2.977
120	2.977	3.012	3.047	3.082	3.117	3.152	3.187	3.223	3.258	3.293	3.329
130	3.329	3.364	3.399	3.435	3.470	3.506	3.541	3.577	3.612	3.648	3.683
140	3.683	3.719	3.755	3.790	3.826	3.862	3.898	3.933	3.969	4.005	4.041

TYPE E
Nickel - Chromium vs Copper - Nickel

Temperature in °C, Reference Junction at 0°C

°C	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
−40	−1.960	−2.008	−2.055	−2.102	−2.150	−2.197	−2.244	−2.291	−2.338	−2.384	−2.431
−30	−1.481	−1.530	−1.578	−1.626	−1.674	−1.722	−1.770	−1.818	−1.865	−1.913	−1.960
−20	−0.995	−1.044	−1.093	−1.141	−1.190	−1.239	−1.288	−1.336	−1.385	−1.433	−1.481
−10	−0.501	−0.550	−0.600	−0.650	−0.699	−0.748	−0.798	−0.847	−0.896	−0.945	−0.995
0	0.000	−0.050	−0.101	−0.151	−0.201	−0.251	−0.301	−0.351	−0.401	−0.451	−0.501
0	0.000	0.050	0.101	0.151	0.202	0.253	0.303	0.354	0.405	0.456	0.507
10	0.507	0.558	0.609	0.660	0.711	0.762	0.813	0.865	0.916	0.967	1.019
20	1.019	1.070	1.122	1.174	1.225	1.277	1.329	1.381	1.432	1.484	1.536
30	1.536	1.588	1.640	1.693	1.745	1.797	1.849	1.901	1.954	2.006	2.058
40	2.058	2.111	2.163	2.216	2.268	2.321	2.374	2.426	2.479	2.532	2.585
50	2.585	2.638	2.691	2.743	2.796	2.849	2.902	2.956	3.009	3.062	3.115
60	3.115	3.168	3.221	3.275	3.328	3.381	3.435	3.488	3.542	3.595	3.649
70	3.649	3.702	3.756	3.809	3.863	3.917	3.971	4.024	4.078	4.132	4.186
80	4.186	4.239	4.293	4.347	4.401	4.455	4.509	4.563	4.617	4.671	4.725
90	4.725	4.780	4.834	4.888	4.942	4.996	5.050	5.105	5.159	5.213	5.268

Temperature in °F, Reference Junction at 32° F

°F	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
0	−0.885	−0.858	−0.831	−0.803	−0.776	−0.748	−0.721	−0.694	−0.666	−0.639	−0.611
10	−0.611	−0.583	−0.556	−0.528	−0.501	−0.473	−0.445	−0.418	−0.390	−0.362	−0.334
20	−0.334	−0.307	−0.279	−0.251	−0.223	−0.195	−0.168	−0.140	−0.112	−0.084	−0.056
30	−0.056	−0.028	0.000	0.028	0.056	0.084	0.112	0.140	0.168	0.196	0.224
40	0.224	0.253	0.281	0.309	0.337	0.365	0.394	0.422	0.450	0.478	0.507
50	0.507	0.535	0.563	0.592	0.620	0.648	0.677	0.705	0.734	0.762	0.791
60	0.791	0.819	0.848	0.876	0.905	0.933	0.962	0.990	1.019	1.048	1.076
70	1.076	1.105	1.134	1.162	1.191	1.220	1.248	1.277	1.306	1.335	1.363
80	1.363	1.392	1.421	1.450	1.479	1.507	1.536	1.565	1.594	1.623	1.652
90	1.652	1.681	1.710	1.739	1.768	1.797	1.826	1.855	1.884	1.913	1.942
100	1.942	1.971	2.000	2.029	2.058	2.088	2.117	2.146	2.175	2.204	2.233
110	2.233	2.263	2.292	2.321	2.350	2.380	2.409	2.438	2.467	2.497	2.526
120	2.526	2.555	2.585	2.614	2.644	2.673	2.702	2.732	2.761	2.791	2.820
130	2.820	2.849	2.879	2.908	2.938	2.967	2.997	3.026	3.056	3.085	3.115
140	3.115	3.145	3.174	3.204	3.233	3.263	3.293	3.322	3.352	3.381	3.411

TYPE J
Iron vs Copper - Nickel

Table 7B-1. Thermocouple Reference Tables (cont)

TYPE JDIN* — Iron vs Copper - Nickel

Temperature in °C. Reference Junction at 0°C

°C	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
0	0.00	0.05	0.10	0.16	0.21	0.26	0.31	0.36	0.42	0.47	0.52
10	0.52	0.57	0.63	0.68	0.73	0.78	0.84	0.89	0.94	1.00	1.05
20	1.05	1.10	1.16	1.21	1.26	1.31	1.37	1.42	1.47	1.53	1.58
30	1.58	1.63	1.69	1.74	1.79	1.84	1.90	1.95	2.00	2.06	2.11
40	2.11	2.16	2.22	2.27	2.33	2.38	2.43	2.49	2.54	2.60	2.65
50	2.65	2.70	2.76	2.81	2.87	2.92	2.97	3.03	3.08	3.14	3.19
60	3.19	3.24	3.30	3.35	3.41	3.46	3.51	3.57	3.62	3.68	3.73
70	3.73	3.78	3.84	3.89	3.95	4.00	4.05	4.11	4.16	4.22	4.27
80	4.27	4.32	4.38	4.43	4.49	4.54	4.60	4.65	4.71	4.77	4.82
90	4.82	4.87	4.93	4.98	5.04	5.09	5.15	5.20	5.26	5.32	5.37

*European Standard

TYPE K — Nickel - Chromium vs Nickel - Aluminum

Temperature in °C. Reference Junction at 0°C

°C	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
−40	−1.527	−1.563	−1.600	−1.636	−1.673	−1.709	−1.745	−1.781	−1.817	−1.853	−1.889
−30	−1.156	−1.193	−1.231	−1.268	−1.305	−1.342	−1.379	−1.416	−1.453	−1.490	−1.527
−20	−0.777	−0.816	−0.854	−0.892	−0.930	−0.968	−1.005	−1.043	−1.081	−1.118	−1.156
−10	−0.392	−0.431	−0.469	−0.508	−0.547	−0.585	−0.624	−0.662	−0.701	−0.739	−0.777
0	0.000	−0.039	−0.079	−0.118	−0.157	−0.197	−0.236	−0.275	−0.314	−0.353	−0.392
0	0.000	0.039	0.079	0.119	0.158	0.198	0.238	0.277	0.317	0.357	0.397
10	0.397	0.437	0.477	0.517	0.557	0.597	0.637	0.677	0.718	0.758	0.798
20	0.798	0.838	0.879	0.919	0.960	1.000	1.041	1.081	1.122	1.162	1.203
30	1.203	1.244	1.285	1.325	1.366	1.407	1.448	1.489	1.529	1.570	1.611
40	1.611	1.652	1.693	1.734	1.776	1.817	1.858	1.899	1.940	1.981	2.022
50	2.022	2.064	2.105	2.146	2.188	2.229	2.270	2.312	2.353	2.394	2.436
60	2.436	2.477	2.519	2.560	2.601	2.643	2.684	2.726	2.767	2.809	2.850
70	2.850	2.892	2.933	2.975	3.016	3.058	3.100	3.141	3.183	3.224	3.266
80	3.266	3.307	3.349	3.390	3.432	3.473	3.515	3.556	3.598	3.639	3.681
90	3.681	3.722	3.764	3.805	3.847	3.888	3.930	3.971	4.012	4.054	4.095

Temperature in °F. Reference Junction at 32°F

°F	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
0	−0.692	−0.671	−0.650	−0.628	−0.607	−0.585	−0.564	−0.543	−0.521	−0.500	−0.478
10	−0.478	−0.457	−0.435	−0.413	−0.392	−0.370	−0.349	−0.327	−0.305	−0.284	−0.262
20	−0.262	−0.240	−0.218	−0.197	−0.175	−0.153	−0.131	−0.109	−0.088	−0.066	−0.044
30	−0.044	−0.022	0.000	0.022	0.044	0.066	0.088	0.110	0.132	0.154	0.176
40	0.176	0.198	0.220	0.242	0.264	0.286	0.308	0.331	0.353	0.375	0.397
50	0.397	0.419	0.441	0.464	0.486	0.508	0.530	0.553	0.575	0.597	0.619
60	0.619	0.642	0.664	0.686	0.709	0.731	0.753	0.776	0.798	0.821	0.843
70	0.843	0.865	0.888	0.910	0.933	0.955	0.978	1.000	1.023	1.045	1.068
80	1.068	1.090	1.113	1.135	1.158	1.181	1.203	1.226	1.248	1.271	1.294
90	1.294	1.316	1.339	1.362	1.384	1.407	1.430	1.452	1.475	1.498	1.520
100	1.520	1.543	1.566	1.589	1.611	1.634	1.657	1.680	1.703	1.725	1.748
110	1.748	1.771	1.794	1.817	1.839	1.862	1.885	1.908	1.931	1.954	1.977
120	1.977	2.000	2.022	2.045	2.068	2.091	2.114	2.137	2.160	2.183	2.206
130	2.206	2.229	2.252	2.275	2.298	2.321	2.344	2.367	2.390	2.413	2.436
140	2.436	2.459	2.482	2.505	2.528	2.551	2.574	2.597	2.620	2.643	2.666

Table 7B-1. Thermocouple Reference Tables (cont)

Temperature in °C. Reference Junction at 0°C

°C	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
0	0.000	0.005	0.011	0.016	0.021	0.027	0.032	0.038	0.043	0.049	0.054
10	0.054	0.060	0.065	0.071	0.077	0.082	0.088	0.094	0.100	0.105	0.111
20	0.111	0.117	0.123	0.129	0.135	0.141	0.147	0.152	0.158	0.165	0.171
30	0.171	0.177	0.183	0.189	0.195	0.201	0.207	0.214	0.220	0.226	0.232
40	0.232	0.239	0.245	0.251	0.258	0.264	0.271	0.277	0.283	0.290	0.296
50	0.296	0.303	0.310	0.316	0.323	0.329	0.336	0.343	0.349	0.356	0.363
60	0.363	0.369	0.376	0.383	0.390	0.397	0.403	0.410	0.417	0.424	0.431
70	0.431	0.438	0.445	0.452	0.459	0.466	0.473	0.480	0.487	0.494	0.501
80	0.501	0.508	0.515	0.523	0.530	0.537	0.544	0.552	0.559	0.566	0.573
90	0.573	0.581	0.588	0.595	0.603	0.610	0.617	0.625	0.632	0.640	0.647

Temperature in F. Reference Junction at 32°F

F	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
0	−0.089	−0.087	−0.084	−0.082	−0.079	−0.076	−0.073	−0.071	−0.068	−0.065	−0.063
10	−0.063	−0.060	−0.057	−0.054	−0.051	−0.049	−0.046	−0.043	−0.040	−0.037	−0.035
20	−0.035	−0.032	−0.029	−0.026	−0.023	−0.020	−0.017	−0.015	−0.012	−0.009	−0.006
30	−0.006	−0.003	0.000	0.003	0.006	0.009	0.012	0.015	0.018	0.021	0.024
40	0.024	0.027	0.030	0.033	0.036	0.039	0.042	0.045	0.048	0.051	0.054
50	0.054	0.057	0.060	0.064	0.067	0.070	0.073	0.076	0.079	0.082	0.086
60	0.086	0.089	0.092	0.095	0.098	0.101	0.105	0.108	0.111	0.114	0.118
70	0.118	0.121	0.124	0.127	0.131	0.134	0.137	0.141	0.144	0.147	0.150
80	0.150	0.154	0.157	0.161	0.164	0.167	0.171	0.174	0.177	0.181	0.184
90	0.184	0.188	0.191	0.194	0.198	0.201	0.205	0.208	0.212	0.215	0.218
100	0.218	0.222	0.225	0.229	0.232	0.236	0.239	0.243	0.246	0.250	0.253
110	0.253	0.257	0.261	0.264	0.268	0.271	0.275	0.278	0.282	0.286	0.289
120	0.289	0.293	0.296	0.300	0.304	0.307	0.311	0.315	0.318	0.322	0.326
130	0.326	0.329	0.333	0.337	0.340	0.344	0.348	0.351	0.355	0.359	0.363
140	0.363	0.366	0.370	0.374	0.378	0.381	0.385	0.389	0.393	0.397	0.400

TYPE R
Platinum vs Platinum -13% Rhodium

Temperature in C. Reference Junction at 0 C

C	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
0	0.000	0.005	0.011	0.016	0.022	0.027	0.033	0.038	0.044	0.050	0.055
10	0.055	0.061	0.067	0.072	0.078	0.084	0.090	0.095	0.101	0.107	0.113
20	0.113	0.119	0.125	0.131	0.137	0.142	0.148	0.154	0.161	0.167	0.173
30	0.173	0.179	0.185	0.191	0.197	0.203	0.210	0.216	0.222	0.228	0.235
40	0.235	0.241	0.247	0.254	0.260	0.266	0.273	0.279	0.286	0.292	0.299
50	0.299	0.305	0.312	0.318	0.325	0.331	0.338	0.345	0.351	0.358	0.365
60	0.365	0.371	0.378	0.385	0.391	0.398	0.405	0.412	0.419	0.425	0.432
70	0.432	0.439	0.446	0.453	0.460	0.467	0.474	0.481	0.488	0.495	0.502
80	0.502	0.509	0.516	0.523	0.530	0.537	0.544	0.551	0.558	0.566	0.573
90	0.573	0.580	0.587	0.594	0.602	0.609	0.616	0.623	0.631	0.638	0.645
100	0.645	0.653	0.660	0.667	0.675	0.682	0.690	0.697	0.704	0.712	0.719
110	0.719	0.727	0.734	0.742	0.749	0.757	0.764	0.772	0.780	0.787	0.795
120	0.795	0.802	0.810	0.818	0.825	0.833	0.841	0.848	0.856	0.864	0.872
130	0.872	0.879	0.887	0.895	0.903	0.910	0.918	0.926	0.934	0.942	0.950
140	0.950	0.957	0.965	0.973	0.981	0.989	0.997	1.005	1.013	1.021	1.029

TYPE S
Platinum vs Platinum -10% Rhodium

Table 7B-1. Thermocouple Reference Tables (cont)

TYPE S — Platinum vs Platinum -10% Rhodium

Temperature in °F. Reference Junction at 32°F

°F	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
0	−0.092	−0.089	−0.086	−0.084	−0.081	−0.078	−0.075	−0.073	−0.070	−0.067	−0.064
10	−0.064	−0.061	−0.058	−0.056	−0.053	−0.050	−0.047	−0.044	−0.041	−0.038	−0.035
20	−0.035	−0.033	−0.030	−0.027	−0.024	−0.021	−0.018	−0.015	−0.012	−0.009	−0.006
30	−0.006	−0.003	0.000	0.003	0.006	0.009	0.012	0.015	0.018	0.021	0.024
40	0.024	0.027	0.030	0.033	0.037	0.040	0.043	0.046	0.049	0.052	0.055
50	0.055	0.058	0.062	0.065	0.068	0.071	0.074	0.077	0.081	0.084	0.087
60	0.087	0.090	0.093	0.097	0.100	0.103	0.106	0.110	0.113	0.116	0.119
70	0.119	0.123	0.126	0.129	0.133	0.136	0.139	0.142	0.146	0.149	0.152
80	0.152	0.156	0.159	0.163	0.166	0.169	0.173	0.176	0.179	0.183	0.186
90	0.186	0.190	0.193	0.197	0.200	0.203	0.207	0.210	0.214	0.217	0.221
100	0.221	0.224	0.228	0.231	0.235	0.238	0.242	0.245	0.249	0.252	0.256
110	0.256	0.259	0.263	0.266	0.270	0.274	0.277	0.281	0.284	0.288	0.291
120	0.291	0.295	0.299	0.302	0.306	0.309	0.313	0.317	0.320	0.324	0.328
130	0.328	0.331	0.335	0.339	0.342	0.346	0.350	0.353	0.357	0.361	0.365
140	0.365	0.368	0.372	0.376	0.379	0.383	0.387	0.391	0.394	0.398	0.402

TYPE T — Copper vs Copper - Nickel

Temperature in °C. Reference Junction at 0°C

°C	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
−40	−1.475	−1.510	−1.544	−1.579	−1.614	−1.648	−1.682	−1.717	−1.751	−1.785	−1.819
−30	−1.121	−1.157	−1.192	−1.228	−1.263	−1.299	−1.334	−1.370	−1.405	−1.440	−1.475
−20	0.757	0.794	0.830	0.867	0.903	0.940	0.976	1.013	1.049	1.085	1.121
−10	0.383	0.421	0.458	0.496	0.534	0.571	0.608	0.646	0.683	0.720	0.757
0	0.000	0.039	0.077	0.116	0.154	0.193	0.231	0.269	0.307	0.345	0.383
0	0.000	0.039	0.078	0.117	0.156	0.195	0.234	0.273	0.312	0.351	0.391
10	0.391	0.430	0.470	0.510	0.549	0.589	0.629	0.669	0.709	0.749	0.789
20	0.789	0.830	0.870	0.911	0.951	0.992	1.032	1.073	1.114	1.155	1.196
30	1.196	1.237	1.279	1.320	1.361	1.403	1.444	1.486	1.528	1.569	1.611
40	1.611	1.633	1.695	1.738	1.780	1.822	1.865	1.907	1.950	1.992	2.035
50	2.035	2.078	2.121	2.164	2.207	2.250	2.294	2.337	2.380	2.424	2.467
60	2.467	2.511	2.555	2.599	2.643	2.687	2.731	2.775	2.819	2.864	2.908
70	2.908	2.953	2.997	3.042	3.087	3.131	3.176	3.221	3.266	3.312	3.357
80	3.357	3.402	3.447	3.493	3.538	3.584	3.630	3.676	3.721	3.767	3.813
90	3.813	3.859	3.906	3.952	3.998	4.044	4.091	4.137	4.184	4.231	4.277

Temperature in °F. Reference Junction at 32°F

°F	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
0	−0.674	−0.654	−0.633	−0.613	−0.592	−0.571	−0.550	−0.529	−0.509	−0.488	−0.467
10	−0.467	−0.446	−0.425	−0.404	−0.383	−0.362	−0.341	−0.320	−0.299	−0.277	−0.256
20	−0.256	−0.235	−0.214	−0.193	−0.171	−0.150	−0.129	−0.107	−0.086	−0.064	−0.043
30	−0.043	−0.022	0.000	0.022	0.043	0.065	0.086	0.108	0.130	0.151	0.173
40	0.173	0.195	0.216	0.238	0.260	0.282	0.303	0.325	0.347	0.369	0.391
50	0.391	0.413	0.435	0.457	0.479	0.501	0.523	0.545	0.567	0.589	0.611
60	0.611	0.634	0.656	0.678	0.600	0.722	0.745	0.767	0.789	0.812	0.834
70	0.834	0.857	0.879	0.902	0.924	0.947	0.969	0.992	1.014	1.037	1.060
80	1.060	1.082	1.105	1.128	1.151	1.173	1.196	1.219	1.242	1.265	1.288
90	1.288	1.311	1.334	1.357	1.380	1.403	1.426	1.449	1.472	1.495	1.518
100	1.518	1.542	1.565	1.588	1.611	1.635	1.658	1.681	1.705	1.728	1.752
110	1.752	1.775	1.799	1.822	1.846	1.869	1.893	1.917	1.940	1.964	1.988
120	1.988	2.011	2.035	2.059	2.083	2.107	2.131	2.154	2.178	2.202	2.226
130	2.226	2.250	2.274	2.298	2.322	2.347	2.371	2.395	2.419	2.443	2.467
140	2.467	2.492	2.516	2.540	2.565	2.589	2.613	2.638	2.662	2.687	2.711

Table 7B-1. Thermocouple Reference Tables (cont)

TYPE TDIN* Copper vs Copper - Nickel

Temperature in °C, Reference Junction at 0°C

°C	0	1	2	3	4	5	6	7	8	9	10
	THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS										
0	0.00	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32	0.36	0.40
10	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80
20	0.80	0.84	0.88	0.92	0.96	1.00	1.05	1.09	1.13	1.17	1.21
30	1.21	1.25	1.29	1.34	1.38	1.42	1.46	1.50	1.55	1.59	1.63
40	1.63	1.67	1.71	1.76	1.80	1.84	1.88	1.92	1.97	2.01	2.05
50	2.05	2.09	2.14	2.18	2.22	2.26	2.31	2.35	2.39	2.44	2.48
60	2.48	2.52	2.57	2.61	2.65	2.69	2.74	2.78	2.82	2.87	2.91
70	2.91	2.95	3.00	3.04	3.09	3.13	3.17	3.22	3.26	3.31	3.35
80	3.35	3.39	3.44	3.48	3.53	3.57	3.62	3.66	3.71	3.75	3.80
90	3.80	3.84	3.89	3.93	3.98	4.02	4.07	4.11	4.16	4.20	4.25

*European Standard

Section 8
Schematic Diagrams

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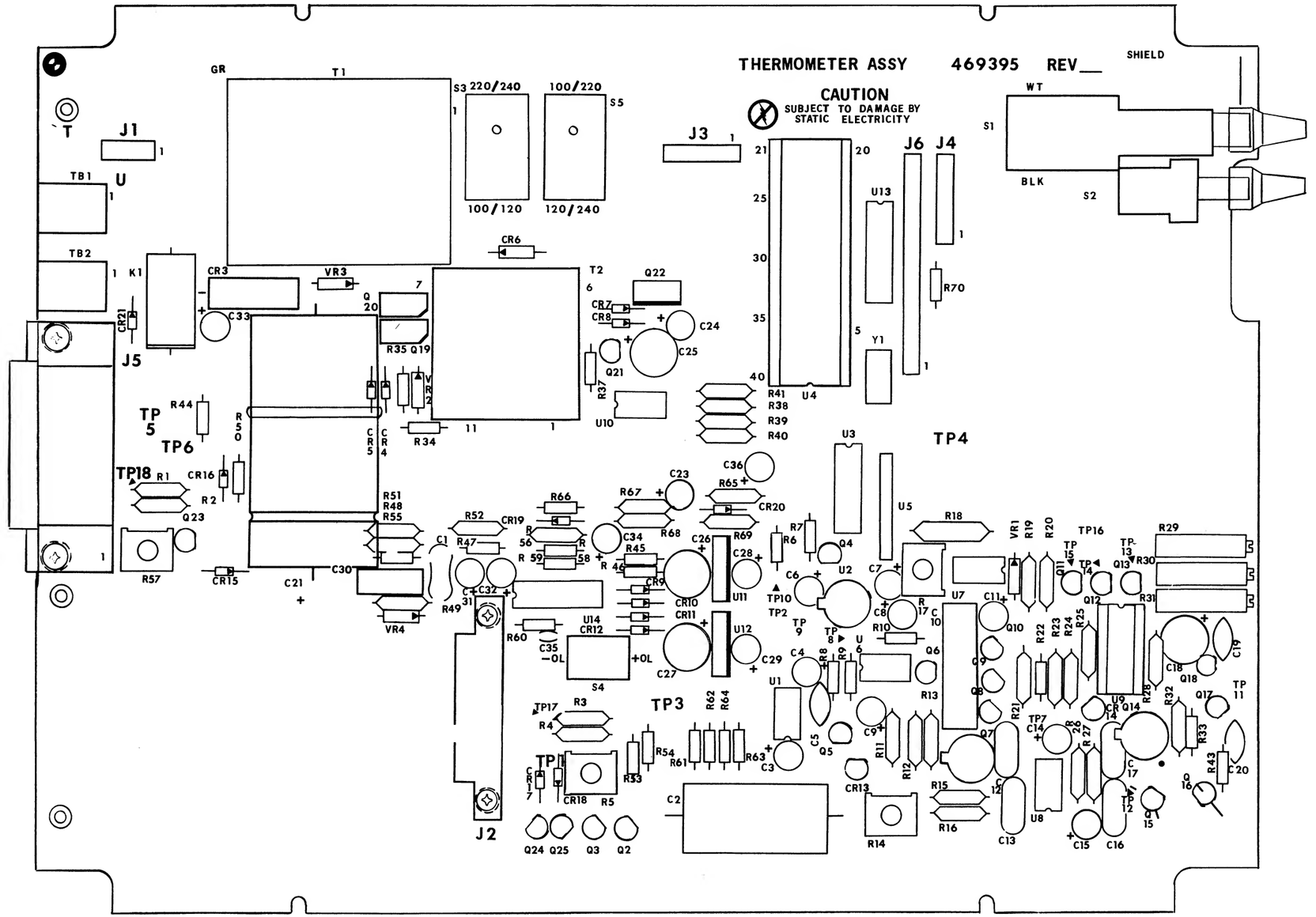
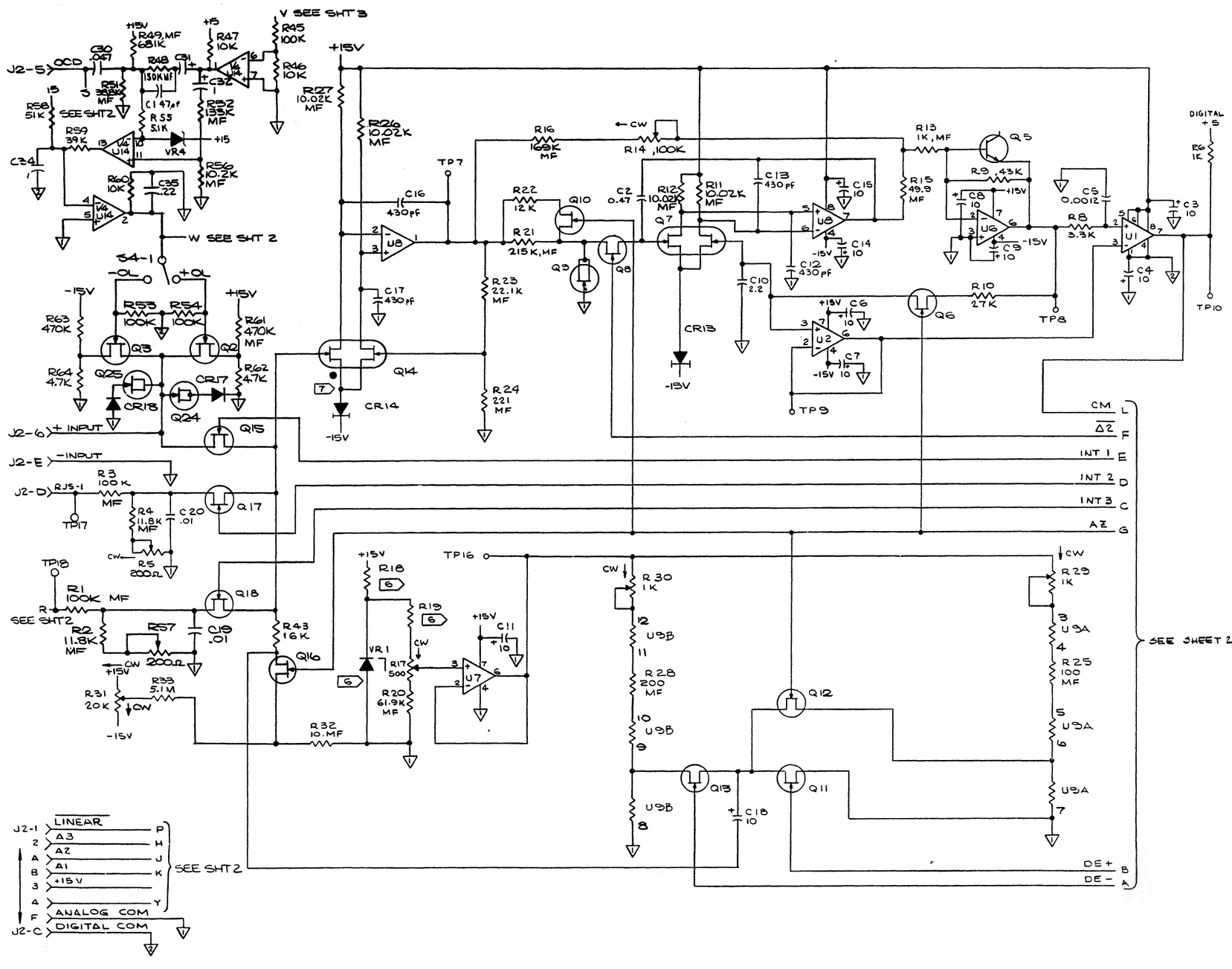


2190A-1601

Figure 8-1. A1 Main PCB Assembly



NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL RESISTANCE IS IN OHMS AND ALL CAPACITANCE IS IN MICROFARADS.
2. ALL RESISTORS ARE ¼W, 5% UNLESS OTHERWISE SPECIFIED.
3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14
4. FOR ASSEMBLY DRAWING SEE 2180A-

   FOR REF. DESIGNATION DRAWING SEE 2180A-
5. ▽ DENOTES ANALOG COMMON (0 VOLTS)

   ▽ DENOTES DIGITAL COMMON. DIGITAL COMMON IS -15V WITH RESPECT TO ANALOG COMMON

   ⫽ DENOTES EARTH COMMON

   WARNING: DO NOT CONNECT ▽ TO ▽ DAMAGE MAY RESULT.

7. LOCATE WITH MARKED GATE IN POSITION SHOWN

REF DES	+5DIG	+15V	▽	▽
U1		5,6,8	1,4	
U2		7	4	
U3	14		7	
U4	40		20,21	
U5				
U6		7		4
U7		7		4
U8		8	4	
U9				7,8
U10			4	5,6
U11				
U12				
U13				
U14		3	12	

REFERENCE DESIGNATION	
LAST USED	NOT USED
C36 T2	
CR21 U14	CR1, CR2
Q25 VR3	Q1
R70	R36, R42
S5	

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(Sheet 1 of 3)

Figure 8-1. A1 Main PCB Assembly (cont)

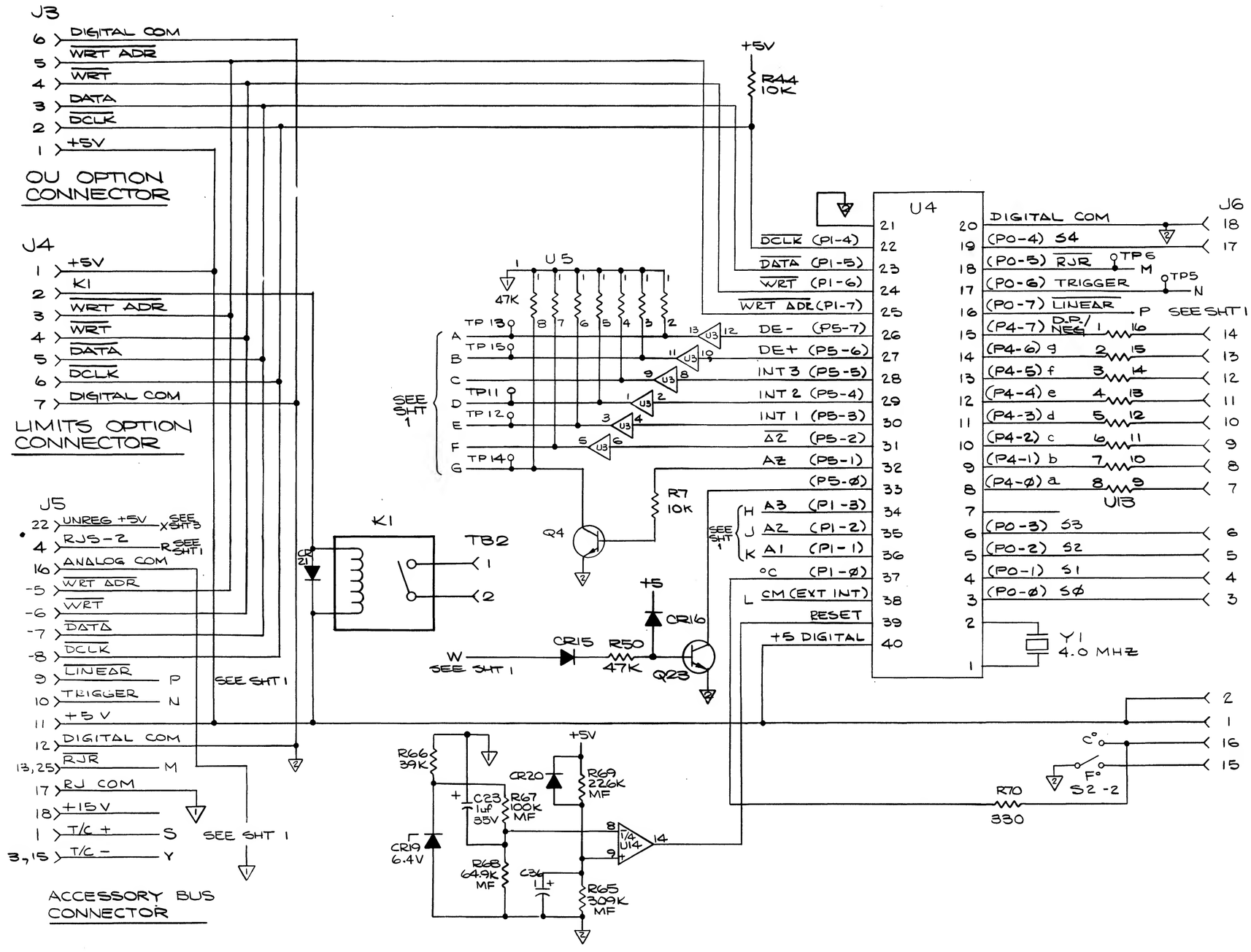

Figure 8-1. A1 Main PCB Assembly (cont)

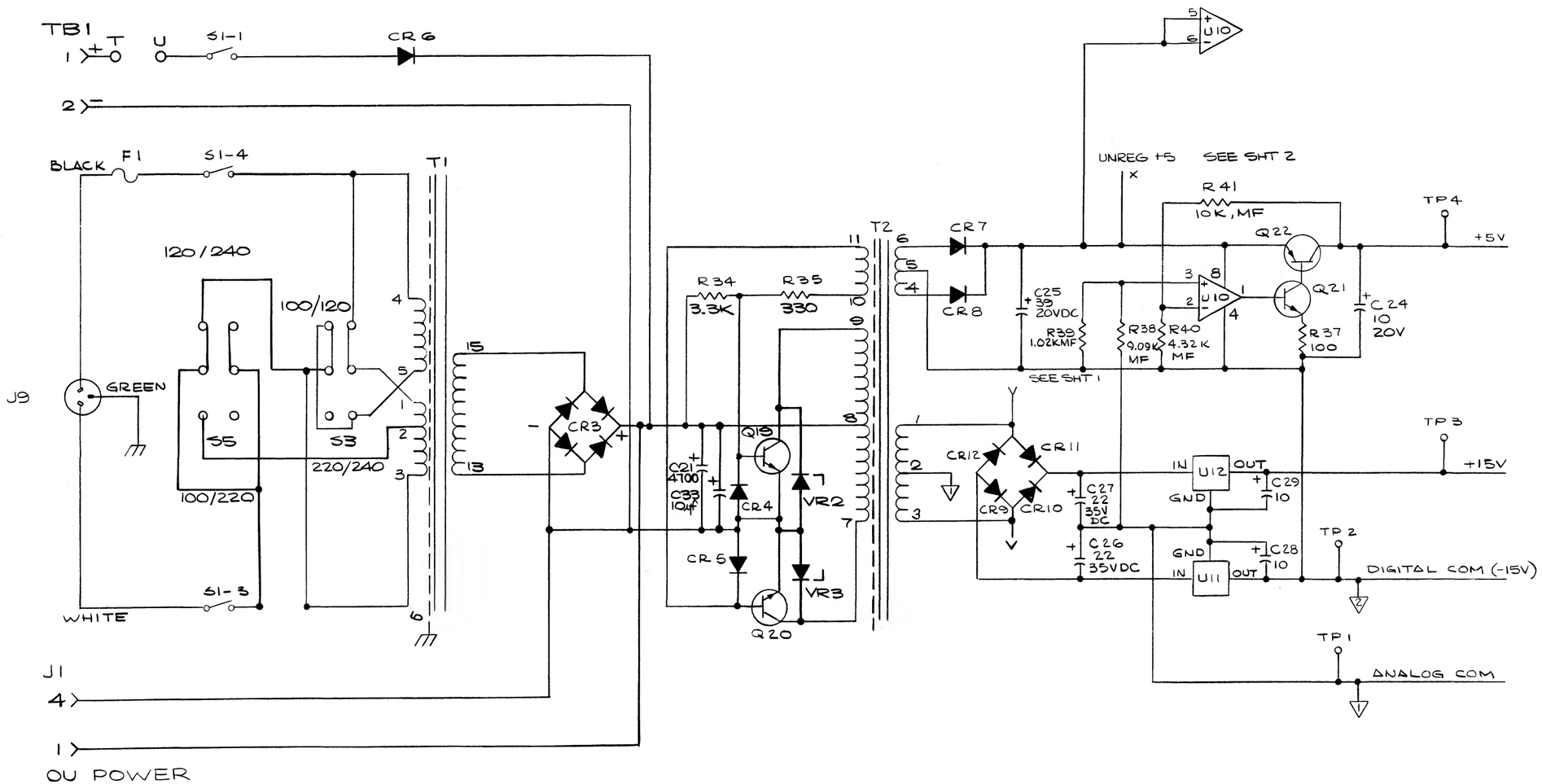

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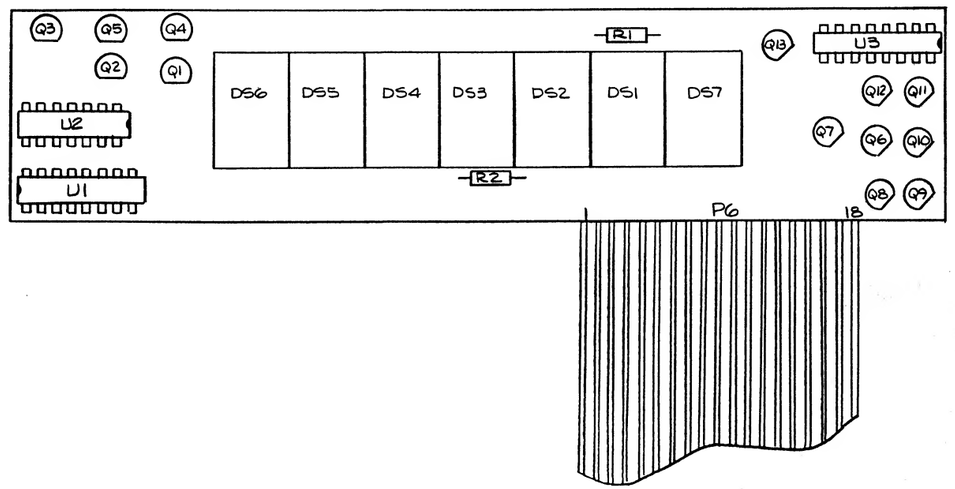
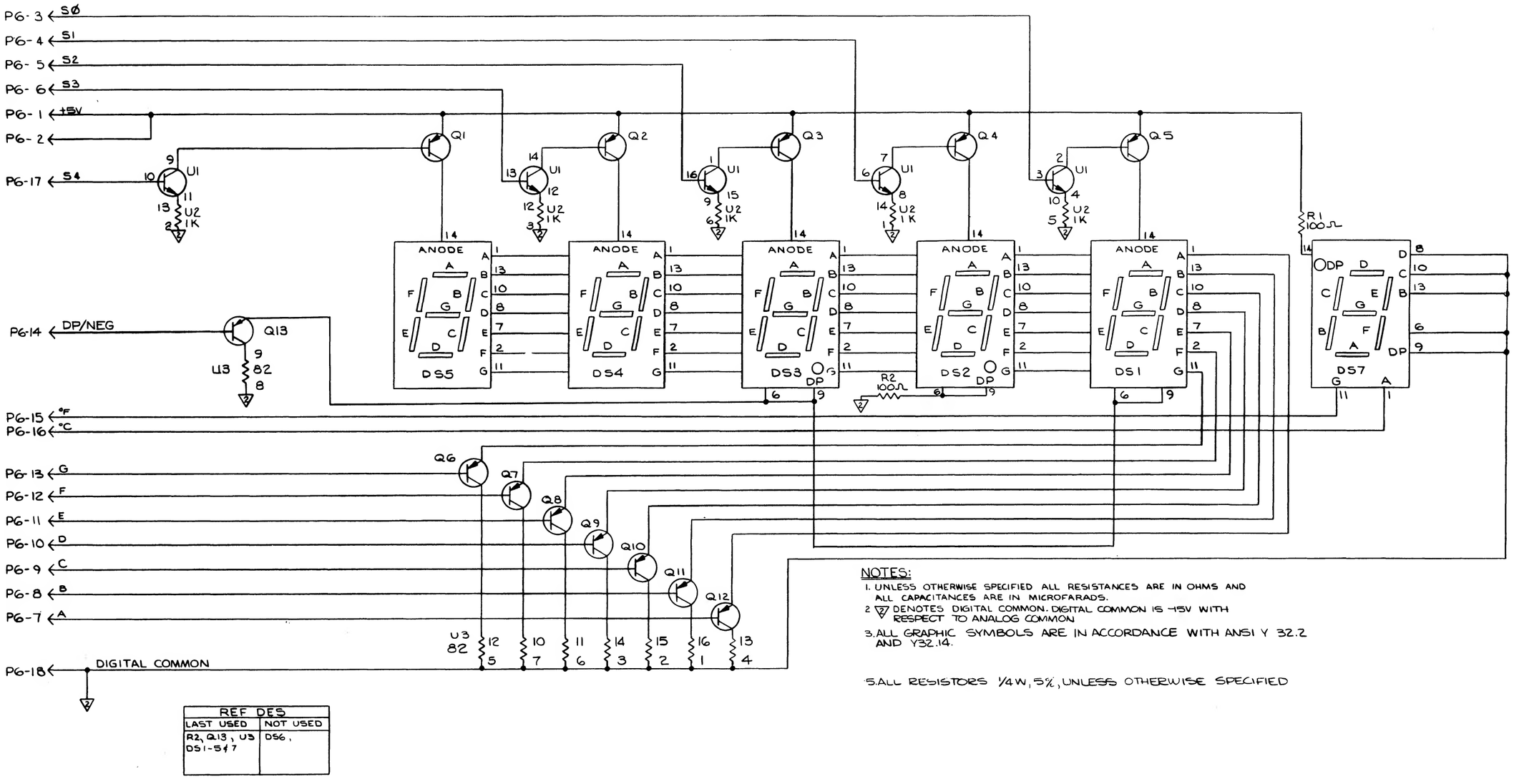
Figure 8-1. A1 Main PCB Assembly (cont)



2190A-1602

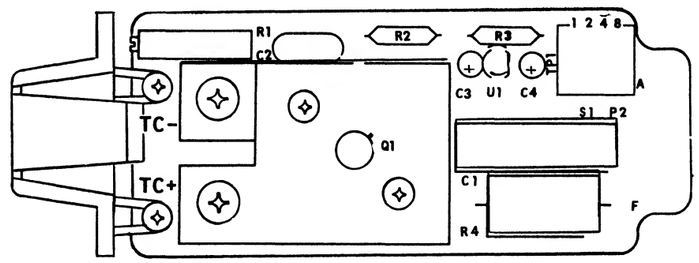
Figure 8-2. A2 Display PCB Assembly



REF DES	
LAST USED	NOT USED
R2, Q13, U3 DS1-5 & 7	DS6,

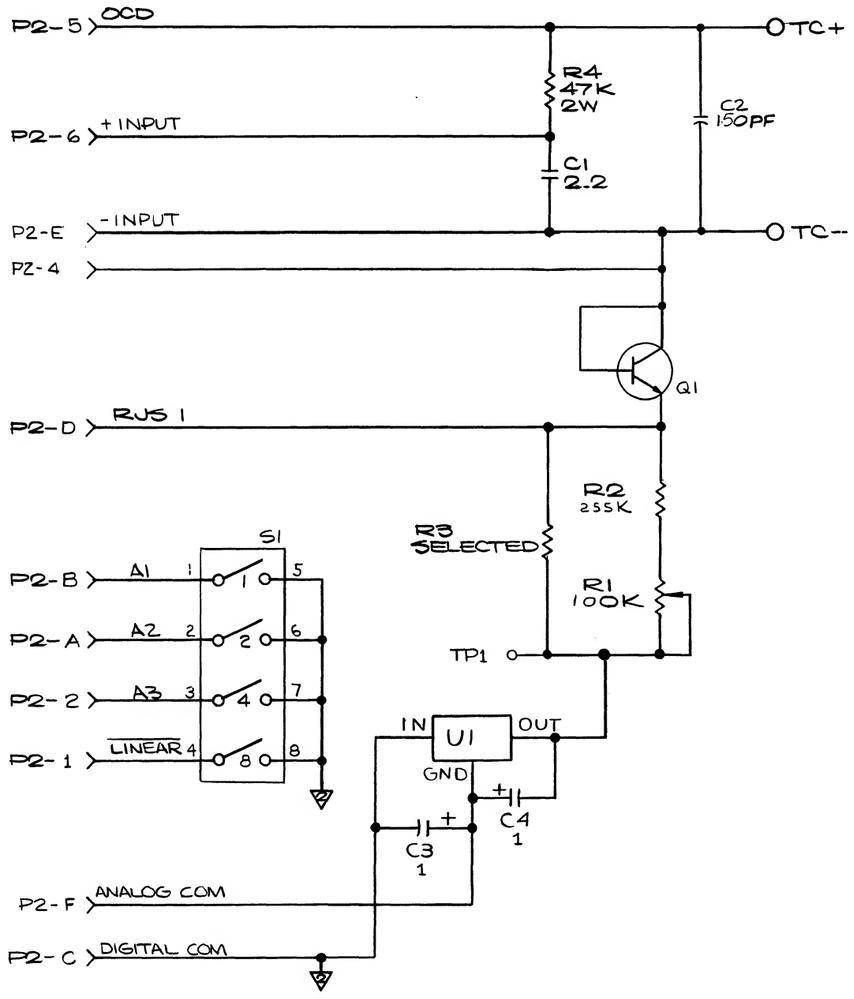
2190A-1002

Figure 8-2. A2 Display PCB Assembly (cont)



2190A-1603

Figure 8-3. A3 Thermocouple Input PCB Assembly



NOTES:

1. UNLESS OTHERWISE SPECIFIED ALL RESISTANCES ARE IN OHMS AND ALL CAPACITANCES ARE IN MICROFARADS.
2. ALL RESISTORS ARE 1/4W, 5% UNLESS OTHERWISE NOTED.
3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.
4. ▽ DENOTES ANALOG COMMON
   ▽ DENOTES DIGITAL COMMON. DIGITAL COMMON IS -15V WITH RESPECT TO ANALOG COMMON

2190A-1003

Figure 8-3. A3 Thermocouple Input PCB Assembly (cont)

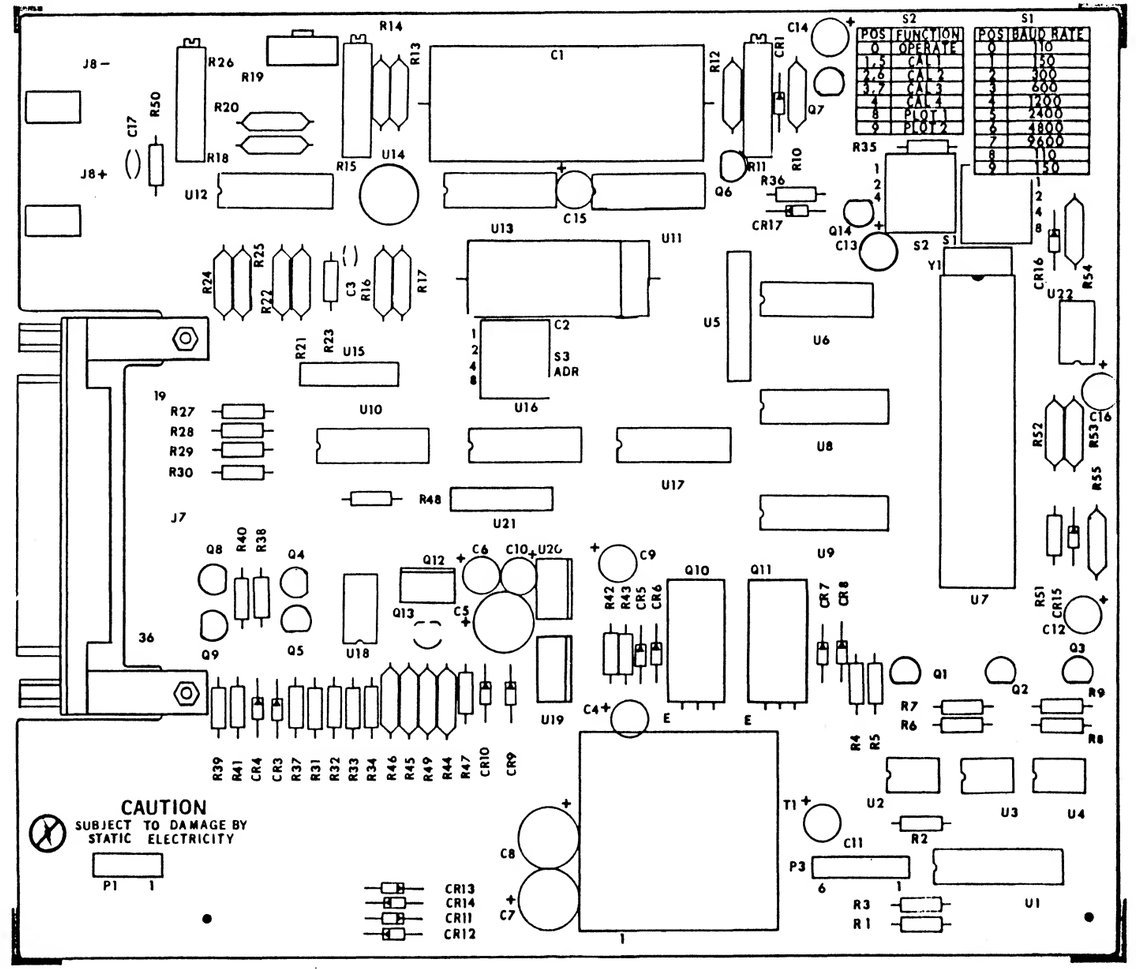


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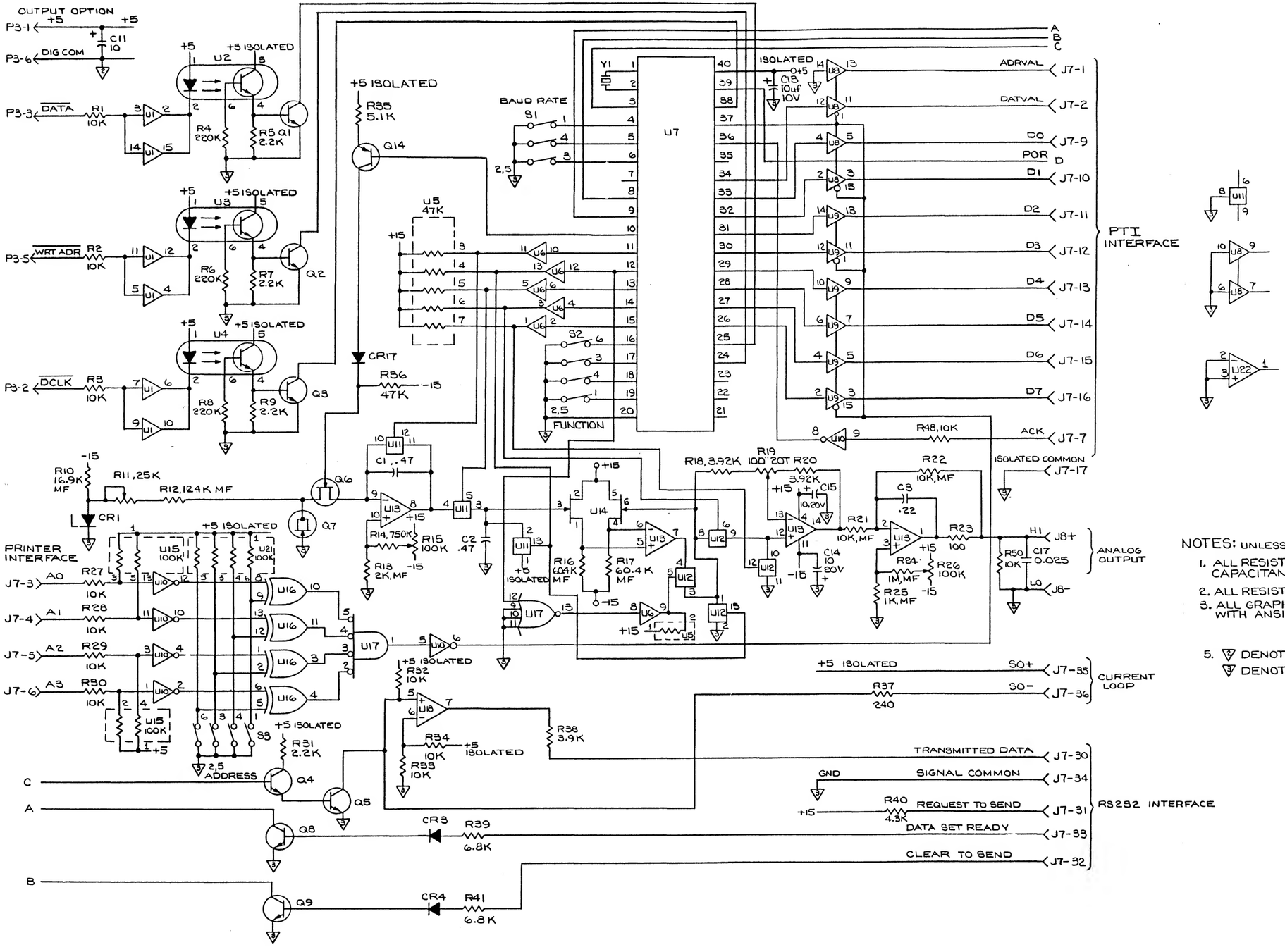
Figure 8-4. Option -002 Output PCB Assembly



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTANCES ARE IN OHMS AND CAPACITANCES ARE IN MICROFARADS
2. ALL RESISTORS ARE 1/4W, 5%
3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.4
5. ▽ DENOTES DIGITAL COMMON
   ▽ DENOTES ISOLATED COMMON

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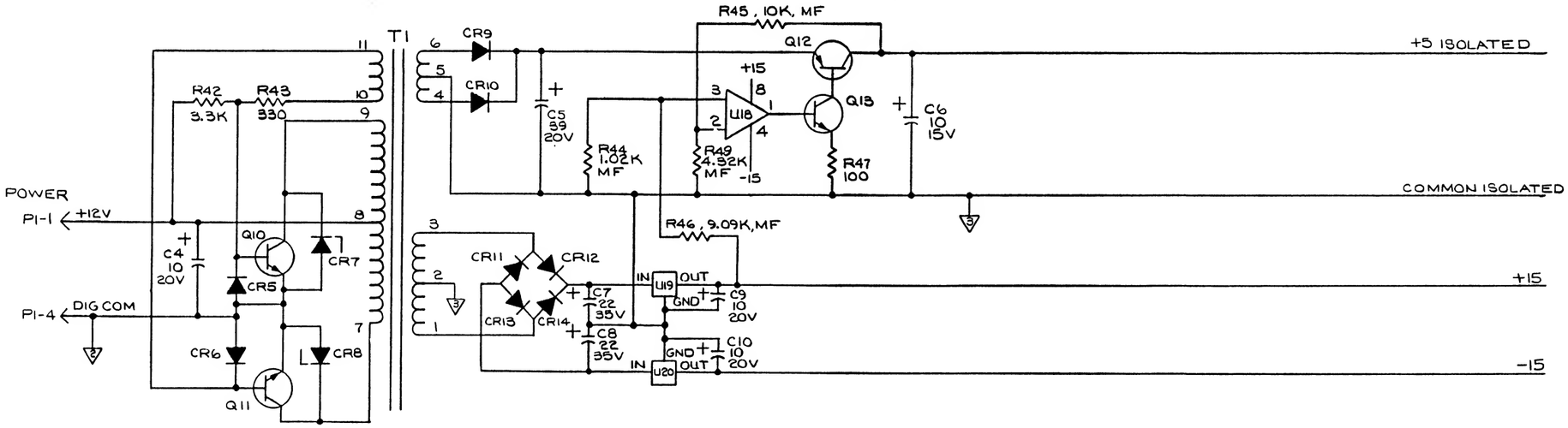
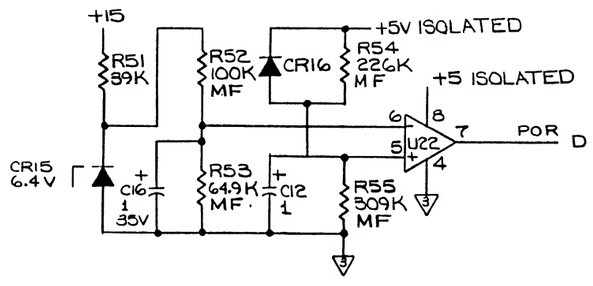
(Sheet 1 of 2)

Figure 8-4. Option -002 PCB Output Assembly (cont)





REF DESIGNATIONS	
LAST USED	NOT USED
C17	
CR17	CR2
U22	
R55	
Q14	
S3	
T1	

DES	+5	GND	+5 ISOLATED	+15	-15	GND ISOLATED
U1	1	8				
U2	1		5			
U3	1		5			
U4	1		5			
U5				1		
U6			14			7
U7			40			20
U8			16			8
U9			16			8
U10			14			7
U11				14		7
U12				14		7
U13				4	11	
U14				2&6		
U15,U21			1			
U16			14			7
U17			14			7
U18				8	4	

DES	+5	GND ISOLATED	+5 ISOLATED	+15	-15	GND ISOLATED
U22		4	8			

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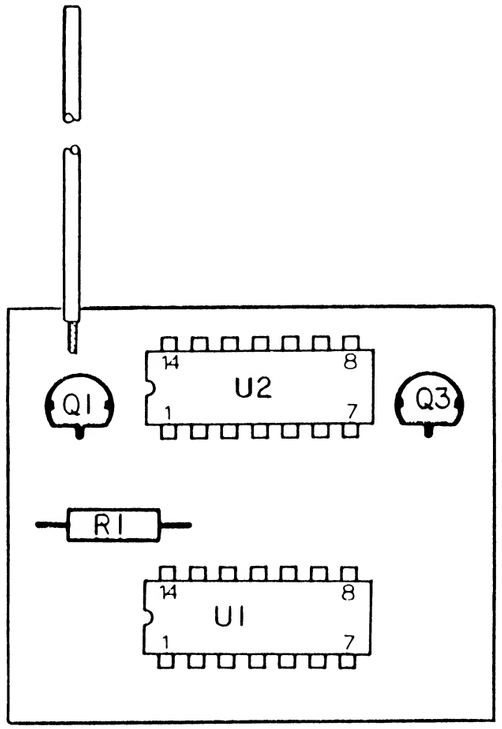
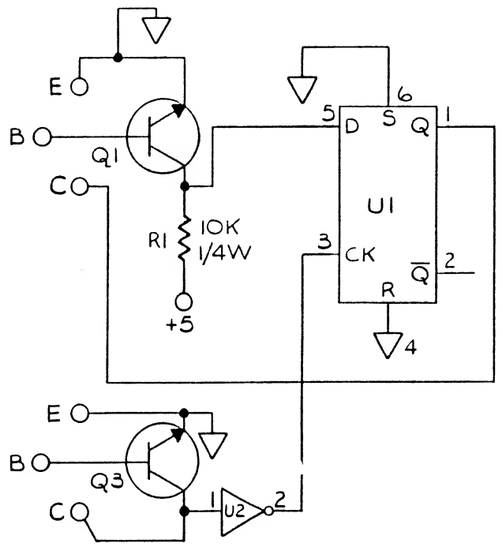
(Sheet 2 of 2)

Figure 8-4. Option -002 PCB Output Assembly (cont)

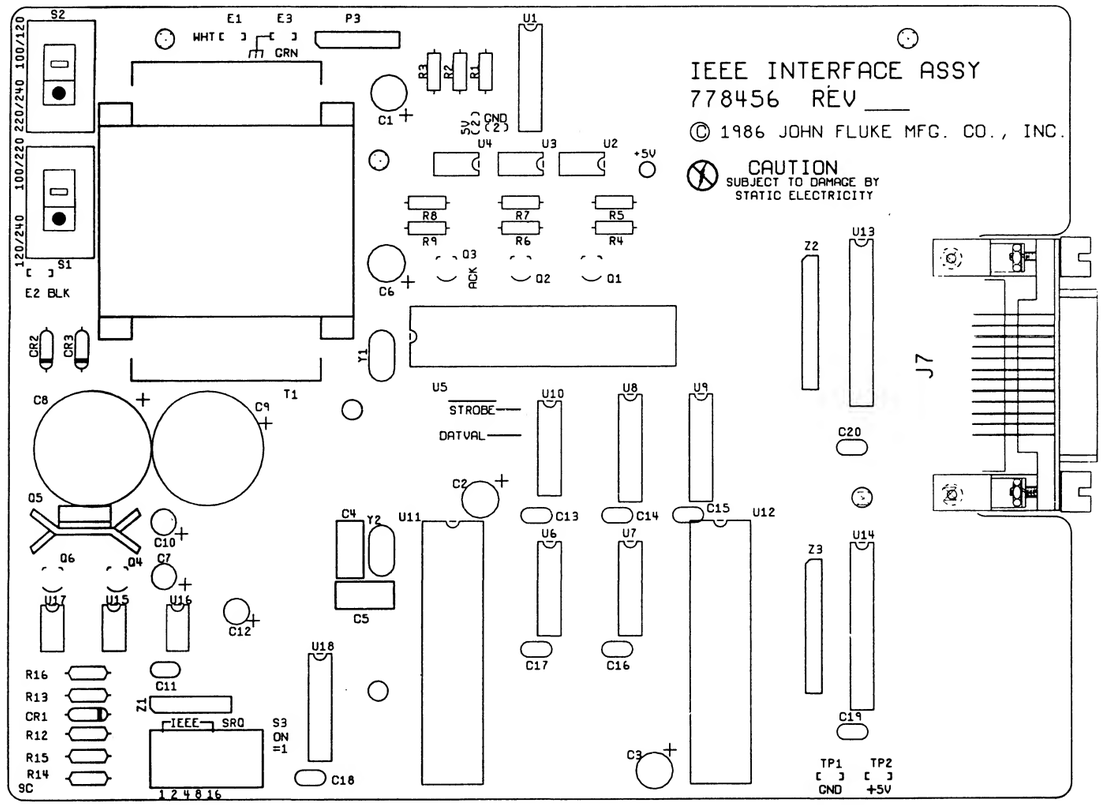


2180A-1621



2180A-1021

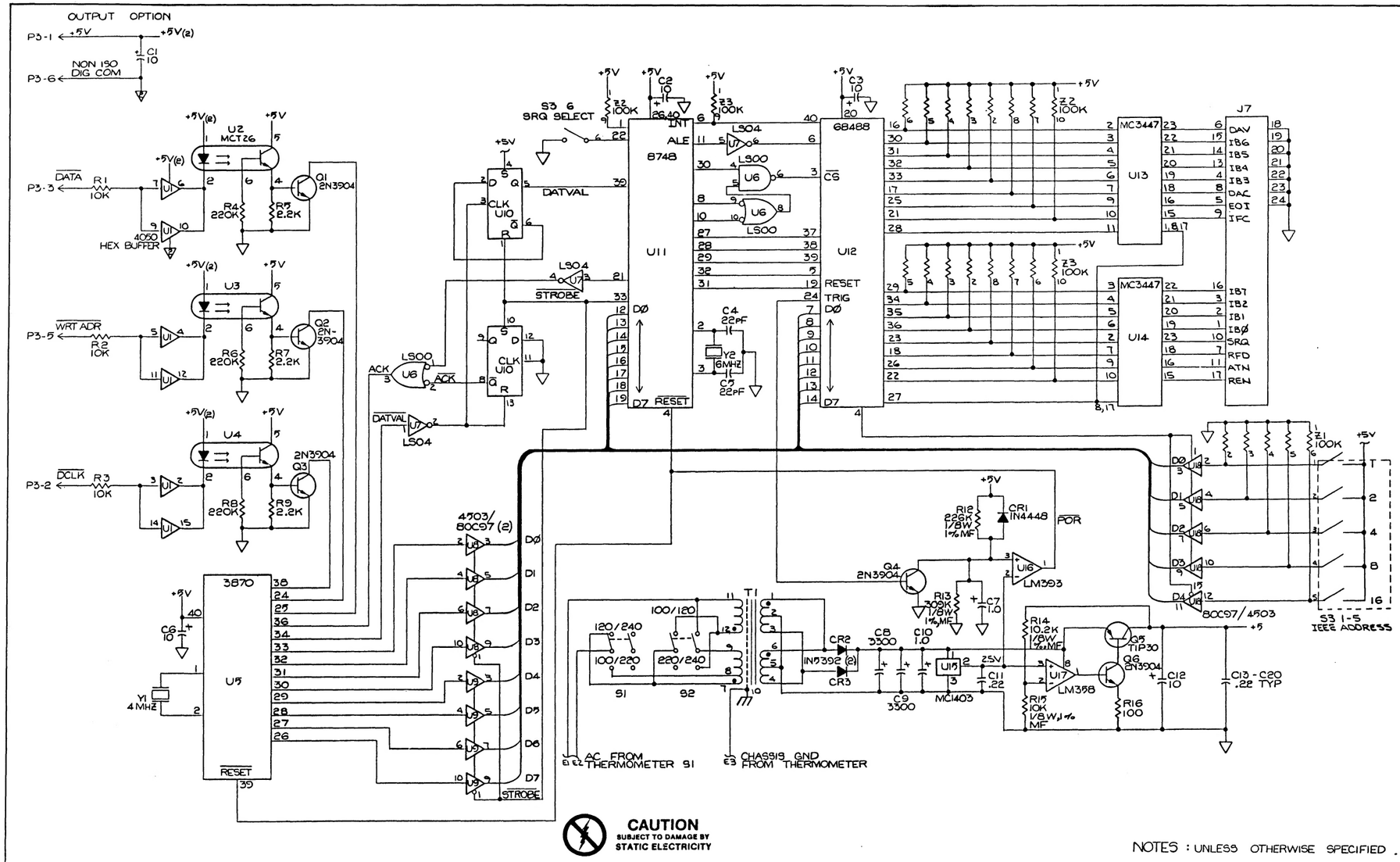
Figure 8-5. Output Unit Adapter PCB Assembly



WARNING: ⊗ INDICATES USAGE OF MOS DEVICE(S) WHICH MAY BE DAMAGED BY STATIC DISCHARGE. USE SPECIAL HANDLING PER S.O.P. 19.1

21X0A-1601

Figure 8-6. Option -004 IEEE-488 Interface PCB Assembly



REF DES	+5(2)	▽	+5	▽	NO CONNECTION
U1	1	8			13,16
U2	1		5		3
U3	1		5		3
U4	1		5		3
U5			40	4,6,20,37	7
U6			14	7,12,13	11
U7			14	7,9,11,13	8,12,10
U8			15,16	8,12,14	11,13
U9			15,16	8,12,14	11,13
U10			4,14	7,11,12	9
U11			26,40	7,20,23, 35,36	9,5,25, 34,37,38
U12			20	1,2	19
U13			24	12,13,14	
U14			1,24	11,12,13,14	
U15			—	3	4,5,6,7,8
U16			8	4	5,6,7
U17			8	4	5,6,7
U18			14,16	8	13
J7					12
S3					8

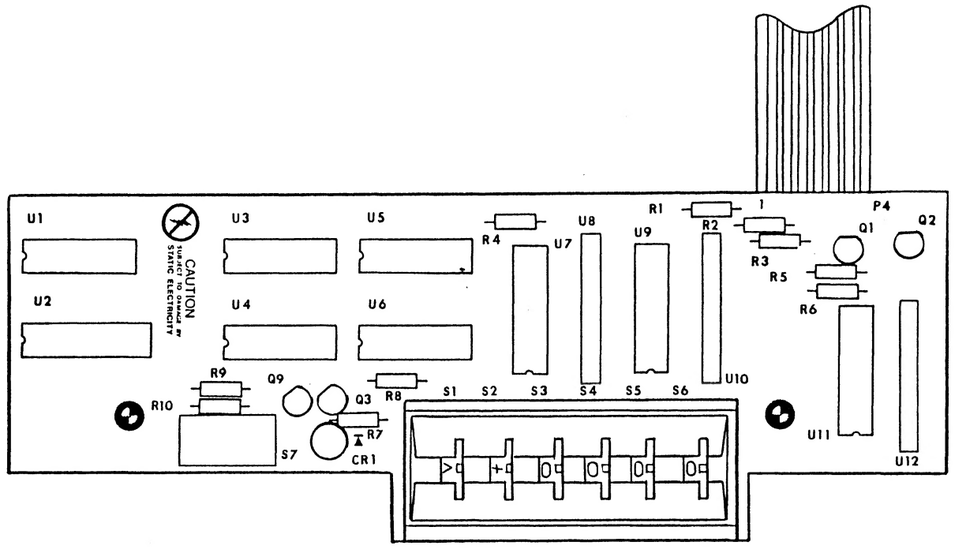
LAST USED	NOT USED
U18	
R16	
C20	
Q6	
CR3	
Y2	
T1	
Z3	
S3	S3 7,8

NOTES : UNLESS OTHERWISE SPECIFIED .

1. ALL CAPACITANCES ARE IN MICROFARADS.
2. ALL RESISTANCES ARE IN OHMS.
3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 AND Y32.14.
4. ALL RESISTORS ARE 1/4 W 5% CARBON FILM.
5. ▽ DENOTES DIGITAL COMMON ISO.
6. ▽ DENOTES DIGITAL COMMON NON-ISO.
7. PINS 3,5,7,8,9,10,11,12,13,14,15,16,17,18,19,21,22,23,35.
8. **WARNING:** ⊗ INDICATES USAGE OF MOS DEVICE(S) WHICH MAY BE DAMAGED BY STATIC DISCHARGE. USE SPECIAL HANDLING PER S.O.P. 19.1

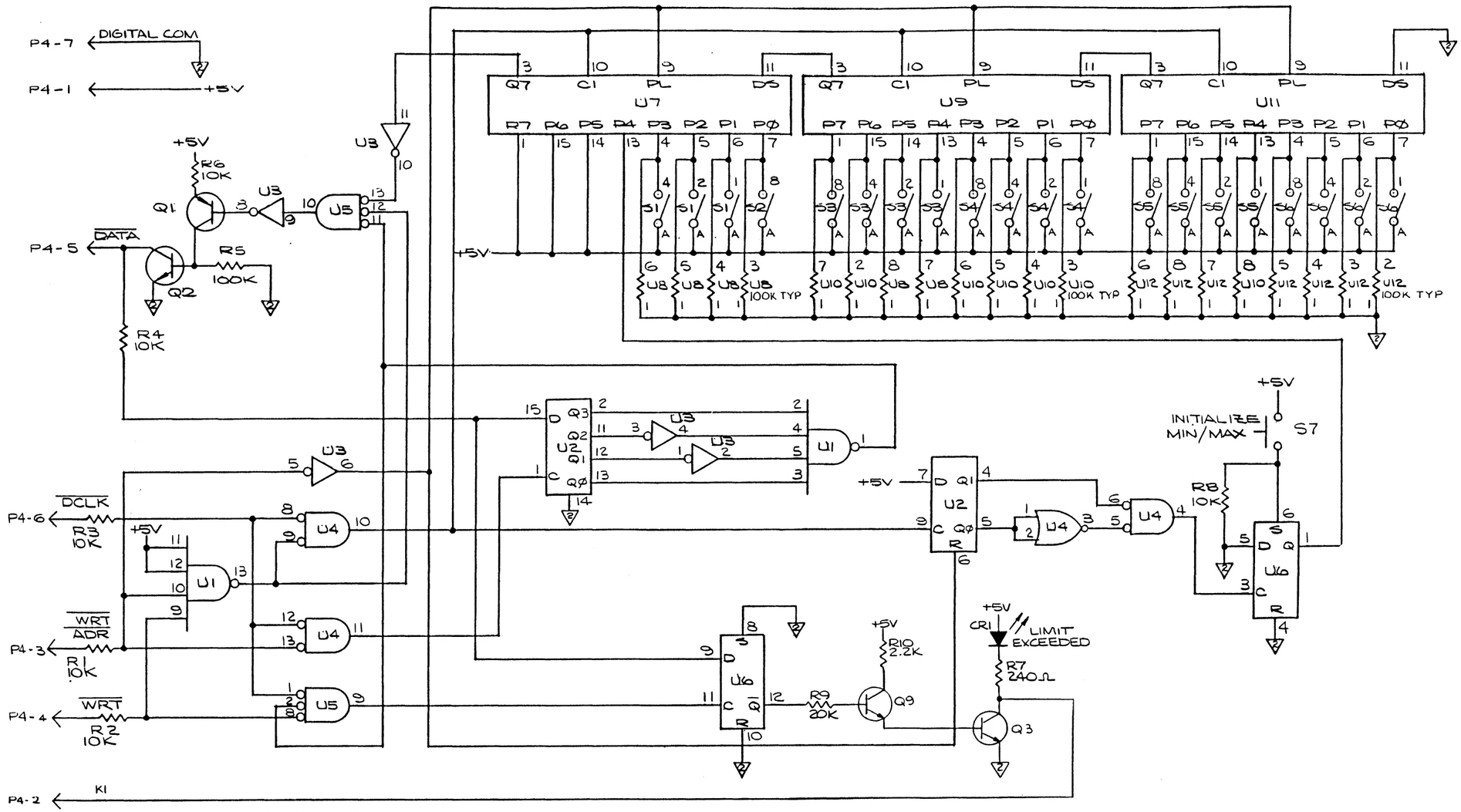
21X0A-1001

Figure 8-6. Option -004 IEEE-488 Interface PCB Assembly (cont)



2180A-1660

Figure 8-7. Option -006 Limits PCB Assembly



NOTES:

1. UNLESS OTHERWISE SPECIFIED ALL RESISTANCES ARE IN OHMS AND ALL CAPACITANCES ARE IN MICROFARADS.
2. ALL RESISTORS ARE 1/4W, 5% UNLESS OTHERWISE NOTED.
3. ALL GRAPHIC SYMBOLS ARE IN ACCORDANCE WITH ANSI Y32.2 & Y32.14.
6. ▽ DENOTES DIGITAL COMMON. DIGITAL COMMON IS -15V WITH RESPECT TO ANALOG COMMON

I.C.	+5V	▽
U1	14	7
U2	16	8
U3	14	7
U4	14	7
U5	14	7
U6	14	7
U7	16	8
U9	16	8
U11	16	8

REF DES	
LAST USED	NOT USED
U12, R8, S7, Q9	Q4, Q5, Q6, Q7, Q8

2180A-1060

Figure 8-7. Option -006 Limits PCB Assembly (cont)

A1–A3	Program Lines
ADRVAL	Address Valid
ANALOG COMMON	Measurement Common
AZ	Auto-Zero
CM	Compare input to the microcomputer
°C	Degrees Celsius
°F	Degrees Fahrenheit
△2	Hold Command
DATA	Data on Bus
DATVAL	Data Valid
DCLK	Data Clock
DE–	Read a minus input
DE+	Read a plus input
DIGITAL COMMON	–15V with respect to Analog Common
DP/NEG	Decimal Point/Negative
INT 1	Integrate unknown voltage 1
INT 2	Integrate unknown voltage 2
INT 3	Integrate unknown voltage 3
LINEAR	Microcomputer Display Linear Counts
OCD	Open Thermocouple Detector
RJ COMMON	Reference Junction Common
RJR	Reference Junction Request
RJS-1	Reference Junction Sense 1
RJS-2	Reference Jucntion Sense 2
S0-S4	Strobe Lines
T/C–	Thermocouple Negative
T/C+	Thermocouple Positive
WRT	Write
WRT ADD	Write Address (Transmitting Address)
–INPUT	Input Negative
+ INPUT	Input Positive

Figure 8-8. Mnemonics